BLACKIE'S SCIENCE READERS

Nos. VI.-VII.

LESSONS ON LIVING

A READING-BOOK IN

PHYSIOLOGY AND HYGIENE

BY

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LONDON

BLACKIE & SON, LIMITED, 50 OLD BAILEY, E.C.

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PREFACE.

The series of readers of which this forms a volume is especially adapted for use in schools in which Elementary Science is taught as a class subject. But, while the scientific facts are accurately presented, the volumes do not pretend to be *manuals* of science. They are distinctively *reading-books*, and the narrative form in which they are cast, together with the native attractiveness of the subjects treated, gives them a sustained interest which fits them for use as general readers in schools where science is not specifically taught.

The subjects selected are those named or suggested in the Schedules of the Education Code, and the reading lessons will prove useful either as introductions to or as adjuncts of the more systematic oral lessons of the teacher.

Each book is illustrated with pictures belonging both to the narrative and the subject-matter, and concludes with a succinct synopsis of the scientific material of the lessons, and explanations of the more difficult words in the text.

The present volume contains simple and informal lessons in Physiology and Hygiene.

CONTENTS.

PART I.

LESSONS ON LIVING.

THE VISIT TO REDCLIFFE.

The day to which our young friend Arthur Cottrell had been patiently looking forward had at

Off for the Holidays.

length arrived. Although he had retired to bed at an early hour the night before, his pleasant

recollections of former birthdays had prevented him from sleeping as well as usual. It was therefore no wonder to find him early astir, and doing all he could to awaken his younger brother Harry.

"Many happy returns of the day, Arthur!" said Harry, as soon as he was sufficiently awake.

"Thank you very much," said Arthur, "but do get up, that's a good fellow; we have still a great deal to do before we make a start for the station."

Arthur was twelve years old that day, and his uncle had invited the two boys to spend a few weeks with him at his home in the quiet country village of Redcliffe.

He was in practice as a physician; and as the number of his patients was not great, he found plenty of time to devote to his nephews when they were staying with him.

Arthur had often expressed to his uncle a wish to become a doctor; and, as the doctor himself was very proud of the profession to which he belonged, he never missed an opportunity of fostering the boy's desire.

As soon as breakfast was over that morning, the two brothers, accompanied by their father, made their way to the railway-station, where they had not long to wait before the train drew up at the platform.

"Is this the train for Redcliffe?"

"Yes, sir," replied the porter, to whom the question had been addressed.

"Jump in, then, my little men," said their father; and having handed in their luggage, he wished them a very pleasant holiday, and told them to pay great attention to everything their uncle said, and not to be afraid to ask a question about anything they did not understand.

As the train rattled along, the chief topic of conversation between the boys was about the contents of a certain box in their uncle's study.

"I wonder what is in it," said Harry.

"So do I," said Arthur. "I have often asked uncle about it, and he has always said that I should know some day when I could understand all he had to tell me."

"Perhaps he will show it us this time," said Harry.

"Very likely," said Arthur; "we must try to coax him."

And so the two boys chatted merrily away until the train arrived at Redcliffe station.

"Here we are," said the boys together; and, quickly gathering their luggage together, they were soon upon the platform and in animated conversation with their uncle and their cousin Ethel, who had come to meet them.

THE PHYSIOLOGY CLASS.

Next day when the doctor had completed his morning rounds, and dinner was over, he led the way to his study, followed by his two nephews.

"Are you going to join my *Physiology Class?*" asked the doctor of Ethel, who was a bright, intelligent girl of about the same age as Arthur.

"What class did you say, father?" said Ethel.

"My Physiology Class."

"What sort of class is that?" asked Ethel.

"I am going to talk about the healthy life of the human body; how its various parts act during health, and what purpose they fulfil towards the body as a whole. That is what I mean by a Physiology Class."

"I should like to join very much," replied Ethel; "but I thought you told Arthur and Harry that you intended talking about the 'houses we live in'."

"So I do. One of the houses I live in is one of the most curious in the world. Not that it is the largest, or the most beautiful, or the most costly; or that it has a large number of rooms filled with costly furniture. But it is nevertheless a most wonderful building, and shows the great skill and wisdom of the Master Workman who planned it. It was the contemplation of his own body which caused David, the inspired psalmist, to exclaim, 'I

am fearfully and wonderfully made'. Now, my little maid, do you recognize one of the houses I live in?"

"Yes, father," said Ethel; "you mean your own body."

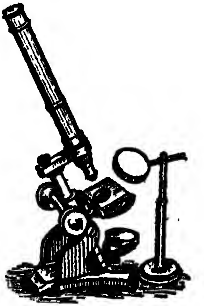
"Exactly! And when you know something of that one, perhaps we may have a talk about those built by man.

"Before beginning our work in real earnest," he continued, "I have something to show you."

"Is it the box, uncle?" cried Harry.

"You shall see that to-morrow," said the doctor smiling.

Here he took a narrow slip of glass from a small cabinet which stood on a side-table.



Microscope.

"Can you read what is upon that, Arthur?" said he, passing the slip of glass to his nephew.

Arthur looked at it intently for a time, but had to confess that he could not see anything to read. Ethel and Harry likewise failed to make anything of it.

"Let me see if I can help you," said the doctor.

With that he took from under a glass shade a microscope; and having placed it upon the table near the window, proceeded to put the glass slip under the instrument.

After explaining that they must close one eye and look down the tube with the other, he asked each of his pupils to take a peep.

"Why, it is the whole of the Lord's Prayer, I declare," said Arthur. "I can read it as easily as the one in my prayer-book."

After Ethel and Harry had also peeped down the tube, the doctor wanted to know how it was that they could not see it on the glass with their eyes alone.

"Because it was too small, I should say," said Ethel.

"Quite right," said her father. "This instrument, however, makes the printing appear larger, and for that reason we call it a microscope; because it enables us to see minute objects which would otherwise be invisible to us."

"Father's spectacles do the same thing when I hold them a certain distance from a newspaper," said Harry.

"And so does this magnifying-glass of mine," said Arthur.

"You are both right," said their uncle, "and if you will look at each end of the microscope-tube you will see a magnifying-glass, as you called it, Arthur. It is by means of these glasses or *lenses* that the objects we examine appear larger. An instrument with one lens only, like a magnifying-glass, is called a *simple* microscope.

"This microscope of mine is known as a *compound* microscope, because it has several lenses placed one above another in the tube. Such an instrument magnifies an object many times; a fact you will find out for yourselves in some of our talks, because we shall use the instrument from time to time as we proceed with our lessons."

THE FRAMEWORK OF THE HOUSE I LIVE IN.

Next day, as soon as the dinner was over, the three pupils took their seats again around the study table. They were followed shortly after by the genial doctor, who was in the best of humour with himself and all the world; for he had thoroughly enjoyed the excellent meal which his wife had prepared that day.

"After what I said yesterday about the microscope," he began, "I think we can safely make another step. To-day I should like to tell you a little about the *framework* of the 'House I live in'."

"And you promised to show us inside that big box," put in Harry.

"What I say I mean, Harry. You shall not be disappointed; for in order to make my lesson intelligible to you I shall have need of its contents."

"But you don't keep the framework of your

house in that box, do you, uncle?" asked Harry in surprise.

"Well, not exactly; but in my body there is a framework similar to the one I shall now show you."

The doctor thereupon thrust his hand into his trouser pocket and drew forth a bunch of keys. Selecting one, he rose and moved towards the box. Instantly his three pupils were on their feet and close by his side, so as to have a better view.

When the lid was thrown open, all three were startled for a moment; for there stood, looking down upon them as it were, the skeleton of a man.

"Oh, the horrid-looking thing!" exclaimed Ethel.

By this time Harry had crept behind his brother, and only took occasional peeps at the grim skeleton in its wooden home.

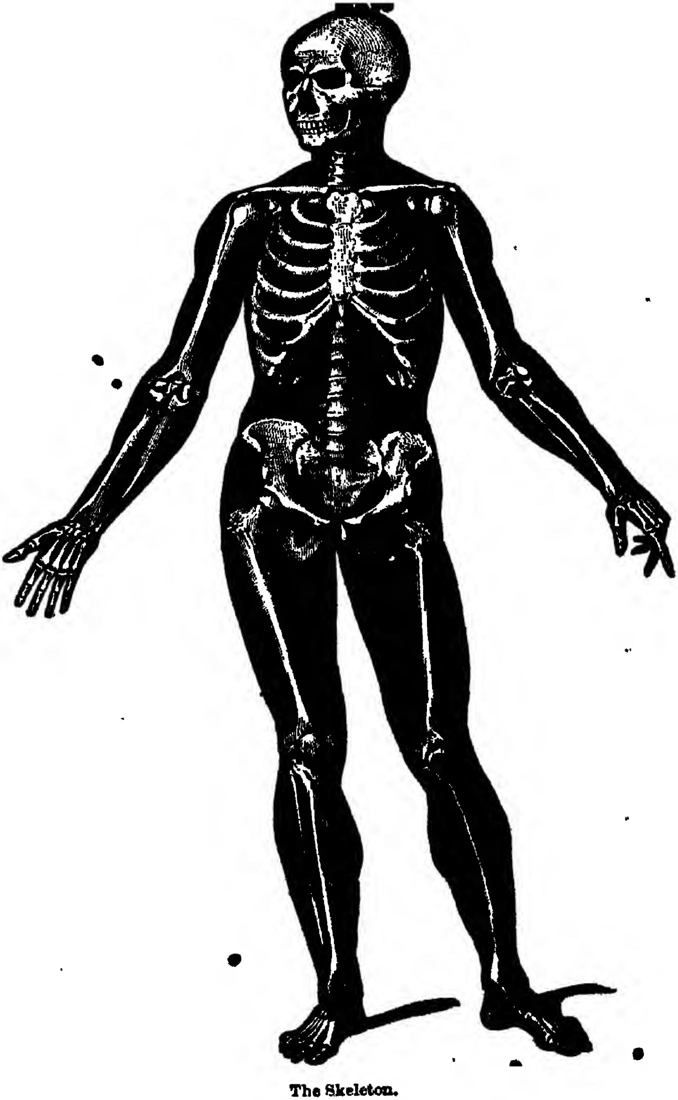
"Is your curiosity satisfied now?" inquired the doctor.

"Oh, yes!" said Arthur, acting as the spokesman for the other two.

"Well, Harry," the doctor went on, "what do you think it looks like?"

"I think it looks like a very, very thin man," was the answer.

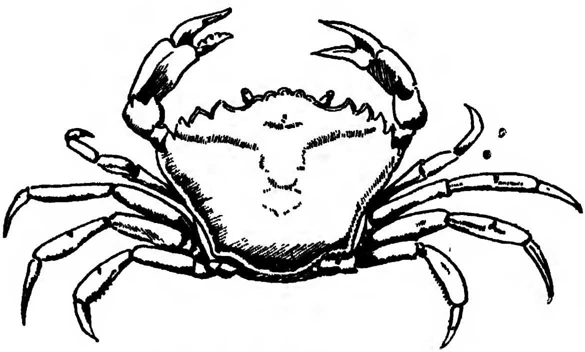
"Well done!" said his uncle. "That is not a bad answer. Although this skeleton looks very different from the living man, still the form of a man is suggested, and no one could possibly mistake it for the skeleton of a cow, or a horse, or of any



The Skeleton.

other animal, except, perhaps, a monkey, whose skeleton closely resembles our own.

"If it were not for this bony framework our bodies would be quite soft, like the jelly-fishes we saw at the sea-side last summer. The bones give



A Shellfish (Crab). Skeleton consists of hard outside shell.

firmness as well as a shape to the body. If you were to count them you would find that there were at least two hundred and forty. In crabs, lobsters, and all shell-fish the skeleton is on the outside, and consists of a shell of carbonate of lime; but the human skeleton is inside.

"Besides giving shape and firmness to the body, the bones serve to protect the various soft and delicate organs within us from injury.

"What organ do you think is contained in here?" asked the doctor, tapping Harry upon the head with his fingers.

"My brain," replied Harry.

"Quite right," said his uncle; "and if there is a part of the body more important than another, that part is the brain. Almost the slightest injury to it is sufficient to cause death; so that you can easily see how necessary it is to have such an organ surrounded by a hard material like bone.

"The third use of the skeleton is to enable us to move. If it were made of one rigid piece of bone we should be no more able to move than a marble statue. Fortunately for us it is not so; and although the bones are joined together in the living body, they are able, in most instances, to move one upon the other. Hence we can bend our knees, close our fists, bow our heads, and perform all the motions our bodies are capable of."

A moment or two later the boys scampered across the fields, and proved beyond a doubt that their skeletons were far from being made in one piece.

MORE ABOUT THE FRAMEWORK.

When the young folks went into the study the next day they found that the doctor had placed several things in readiness for the afternoon's talk. One of these was the bone from a leg of mutton.

"Before you take your seats," began the doctor, "I want you to come with me into the kitchen to

see a simple experiment or two I shall perform; for I fully believe in the old saying that 'a yard of seeing is worth a mile of hearing'."

As the doctor finished his last sentence he took up the mutton-bone and proceeded to the kitchen, where a bright red fire was burning in the range. After carefully weighing the bone he placed it in the hottest part of the fire, at the same time asking his pupils to note what happened. It soon began to burn, and after a while only a red-hot mass of bone was to be seen.

With a pair of tongs the doctor removed it from the fire and put it in the scales again. This time it was found to be lighter; in fact, it had lost about one-third of its weight. All the soft or animal part had been burned away, and only the mineral or earthy portion remained.

Before the bone had quite cooled, the impulsive Harry suddenly grasped it; and, dropping it as suddenly when he found how hot it was, it broke in pieces on the floor. Thus in a very practical manner he learned that the burnt bone was much more brittle than a natural one. Returning to the study the doctor went on to explain another experiment he had performed.

"Here," he said, "is the bone from the wing of a fowl which I have kept in this bottle of dilute hydrochloric acid for a few days. When I take it out and try to bend it you see I can easily do so,

for it is now quite soft and flexible. The acid has dissolved all the mineral matter in the bone, and nothing remains but the animal portion or gristle. Indeed it now resembles the bones in an infant; and this shows how careful elder brothers and sisters should be in handling the baby—a matter I shall speak about in one of my next talks.

Diagram of the Shoulder Joint (ball-and-socket). S, Scapula; Gl, Glenoid cavity, into which H, the head of the Humerus, fits.

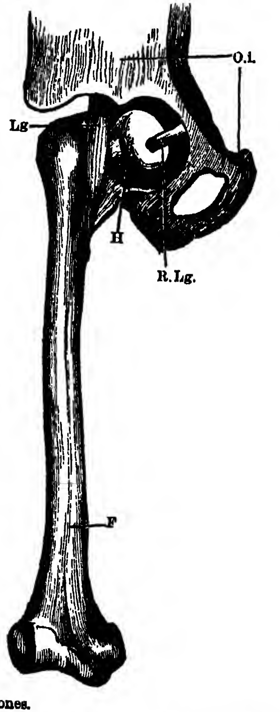
"The places where bones join together are called the *joints* or *articulations.* A joint which, like the shoulder-joint, can be moved

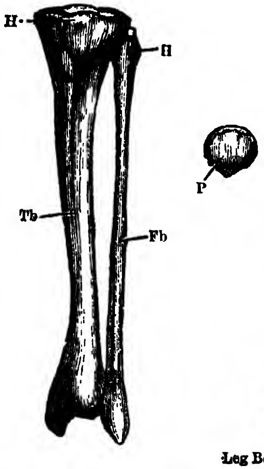
The Bones at the Elbow (hinge joint) held in position by Ligaments

in every direction, is known as a *ball-and-socket joint.* When the joint only allows of a backward and forward movement we have a *hinge joint,* so called because the movement is like that of a door upon its hinges. The knee and elbow are joints of this kind.

"To ensure perfectly free movement it is neces-

sary that one bone should glide easily over its neighbour; but, at the same time, it must not be allowed to slip out of place. To guard against such an occurrence the one bone is bound to the other by some very strong cords called *ligaments.* Still such accidents do happen from time to time."





Leg Bones.

F, Femur; H, head; Lg, ligament; R. Lg., round ligament; O. i., os innominatum; P, patella; Tb, tibia; H, head; Fb, fibula; H'; head.

"I remember hearing father tell some time ago," said Arthur, "how a friend of his had put his foot out of joint through slipping upon a piece of orange-peel."

"That is a common accident," said his uncle. "Thoughtless people often throw orange-peel upon the pavement, and then some unfortunate pedestrian, not noticing the peel, slips upon it, and, by giving the ankle a severe twist, puts his foot out of joint. The same thing may happen through wearing boots with high heels."

"After what you have told us, father," said Ethel, "I shall be more careful in future where I throw my orange-peel. No one shall say that I was the cause of twisting his ankle."

"Very good; and don't forget the dangers of high-heeled boots as well."

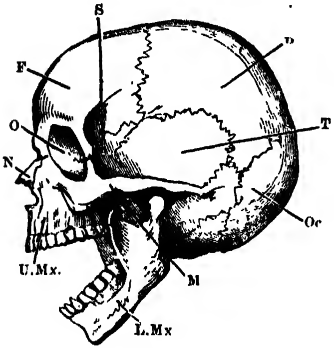
"During the last football season one of my school-mates fell heavily on the ground," said Arthur, "and dislocated his arm."

"Yes. When a bone is pushed out of its proper place it is called a *dislocation.* Some bones are dislocated more easily than others. The thigh-bone, on account of the manner in which it is joined to the hip-bone, is rarely put out of joint.

"And here, perhaps, we had better put the lesson out of joint, so that you may get out into the open air; but remember we 'set' the joint again to-morrow afternoon."

THE FRAMEWORK IS PULLED TO PIECES.

The next day the skeleton was again brought out; but this time the doctor began to pull it to pieces for the purpose of explaining its different parts. As he did so he pointed out that the skeleton could be considered to consist of three main parts. First, there were the bones of the head, known together as the *skull*; then the bones of the *limbs*, including those of the two arms and the two legs, with the hands and feet; and lastly, the bones of the *trunk*.



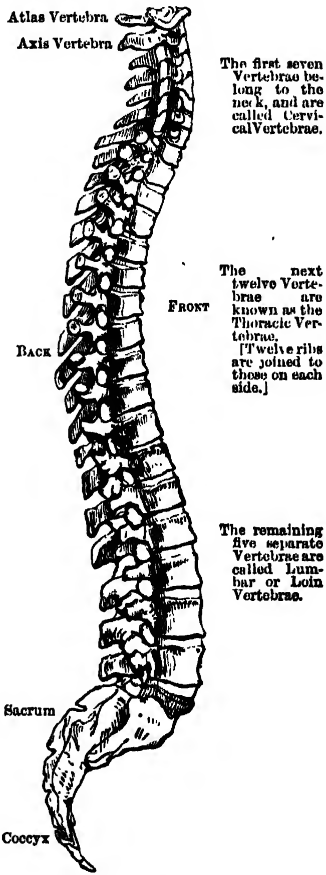
Bones of the Skull.

F, Frontal; P, parietal; Oc, occipital; T, temporal; S, sphenoid; O, orbit; U. Mx., upper maxillary; M, malar; N, nasal; L. Mx., lower maxillary.

"The skull", continued the doctor, "is made up of twenty-two bones, eight of which belong to the head proper or *cranium*, and fourteen to the face. In grown-up people the eight bones of the cranium are joined together by zigzag edges, somewhat like the teeth of a saw, and form what may be called seams. In infancy there are spaces between the bones, and you may see the throbbing of the brain at the top of the head quite easily. As the child grows older the bones gradually approach each other by growing at the edges; but they are not

completely joined together until the child has reached adult age, and the brain its full size.

"Coming to the trunk, or that portion of the body which remains after the head and the limbs have been removed, we see a strong pillar of bones running from the neck to the lower extremity of the trunk. This is known by several names, such as the *backbone*, the *spine*, or the *vertebral column*. In early life it consists of thirty-three separate bones called *vertebræ*; but in adult age several of the lower ones grow together to form single bones. So that in this skeleton you would only find twenty-six.



The Vertebral Column.

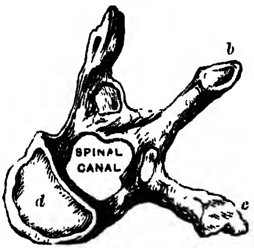
"If the vertebræ be examined there will be found a kind of ring at the back of each one; so that when they are placed one above another in

the position which they occupy in the living body, the rings form a continuous tube through the spine, called the *spinal canal.*"

Arrangement of Cotton-reels with Cork Pads between, to illustrate construction of Vertebral Column.

To make this point perfectly clear to his pupils the doctor placed a number of empty cotton-reels one on the other, so as to form one long tube. To make the model the more complete, he cut up a good-sized cork into circular pads about a quarter of an inch in thickness. After making a hole in the centre of each, he placed one piece of cork between each pair of reels, to represent, as he said, the pads of gristle which are found between the vertebræ in the human backbone.

Resuming his talk, he next explained that during life the spinal canal was filled with a soft substance, very much like the marrow of other bones, and known as the *spinal cord.*



Top view of a Single Vertebra, showing the processes (*a, b, c*), the Spinal Canal, and the Pad of Cartilage, *d.*
b, the spinous process.
a and *c*, the two transverse processes.

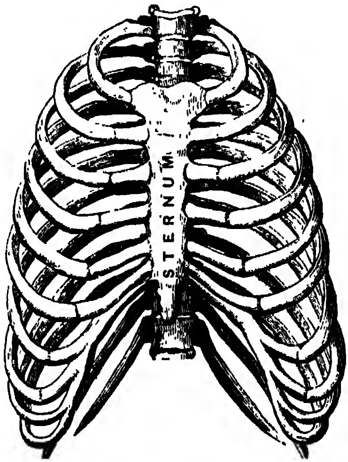
"Now, what do we call this cage-work of bones, Harry?" asked his uncle, pointing to the upper part of the backbone.

"Those are the ribs," said Harry

"And how many ribs can you count?"

'Twelve down each side," said Harry.

"Yes; or as we generally say, twelve pairs," added the doctor. "They spring from the backbone; and, after curving round the sides and front of the chest, are attached to the breastbone. The eleventh and twelfth pairs form an exception, and are not attached to the breastbone, hence they are often called the *free* or *floating* ribs.



The Ribs and Sternum.

The remaining bones of the trunk that should be noticed are those which form a kind of basin at the lower end of the backbone. They are very firm and strong in grown-up persons, but are less so in children, and in children they are, moreover, separate, in order to allow of growth.

"To complete our lesson of to-day, I must say a few words about the limbs. Each upper limb consists of three parts, the *upper arm*, the *fore-arm*, and the *hand*; and each lower limb also consists of

three parts, the *thigh*, the *lower leg*, and the *foot*. In each limb there are thirty bones. There is, however, one important difference between the upper and lower limbs. In front of the knee there is a small plate of bone called the knee-cap or *patella*; but there is no bone answering to this at the elbow. Otherwise the bones of the two sets of limbs are arranged in a similar manner."

"AS THE TWIG IS BENT THE TREE'S INCLINED."

The third lesson in physiology began by the doctor asking his nephews if they had noticed how the fruit-trees in the garden this year were loaded with fruit. Harry admitted that he had, and that his brother and he had done their best to lighten them.

"There is no harm in that," said their uncle; "but do not be tempted to eat too much fruit, or else I shall have you as patients instead of pupils. A proper amount of fruit taken each day is very beneficial, but too much is injurious. But did you notice what I have had to do to several of the trees?" he asked.

"Yes," said Arthur; "you have propped up some of the boughs with stout poles."

"And what was my object in so doing?"

"You were afraid that the weight of the fruit would perhaps break off the boughs and so spoil your trees," said Arthur.

"Exactly; and just as a plant or tree may be made to grow crooked by too great a weight of foliage or of fruit, so may the human frame be forced out of shape or deformed by the negligent use of certain parts, or by putting too great a strain upon it at an early age.

"If we all knew when we were young the terrible harm we might do to ourselves by carrying very heavy weights or by wearing unhealthy clothing, I am sure we should not be so foolish as to continue doing so.

"The bones in children are very different from those in adults. In children and youths the bones consist of gristle, and are easily bent if any unreasonable weight is put upon them. As age advances, the gristle slowly changes to hard bone; but whatever shape the gristle has been forced into during youth, the bones later on will be exactly of the same shape unless the defect has been remedied.

"One of the commonest deformities met with in children is 'bent legs'. There is a disorder called *rickets*, in which the bones are softer than they should be, and in which the softness of the bones continues to a later age than it should do. The disorder arises chiefly from unhealthy surroundings. Impure air of close rooms, especially close bed-rooms,

poor clothing, bad feeding, and late hours, are all causes of rickets.

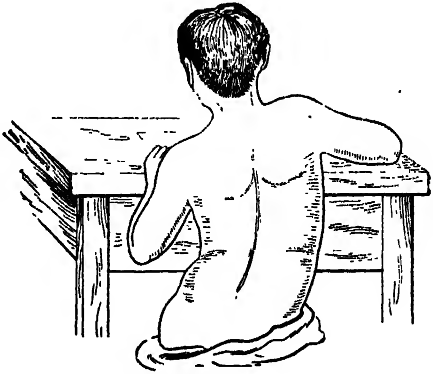
"The result of this disease is that when the child begins to walk the bones give or yield under the weight of the body. And so occurs a very common form of bone deformity. Bad surroundings give rise to rickets, which cause soft bones; and too early weight on the limbs makes the soft bones bend out of shape. In this way many children grow up bow-legged or *bandy*.

"It is commonly believed that the bones will straighten themselves as the children grow older; but a greater mistake could not possibly be made. Whenever a child is seen to 'waddle' in walking, or fall about more than other children, it is pretty certain that there is something wrong with its legs; and if, after placing the feet together—toe to toe and heel to heel—the bones of the leg are not seen to be straight, the advice of a doctor should be obtained."

"Talking of deformed limbs," said Arthur, "reminds me that we met poor Fred Merton whilst we were out yesterday. He seems to be getting more and more deformed each time I meet him."

"I am glad you mentioned Fred, because another lesson can be learnt from his sad case. You know his parents are very poor; and little Fred has been glad to do all sorts of odd jobs to earn a livelihood. Now through carrying his heavy loads chiefly on

the one arm, he has pulled his backbone out of its natural straight shape. At first this bending of the backbone is not readily noticed because of the clothing; consequently it may develop, as in Fred's case, to such an extent that little can be done for the sufferer.


Curvature of the Spine.

"The same thing may happen to a girl who is employed in nursing and carrying a baby. It often happens to be more convenient to carry the baby always on the same arm, and the weight being thrown on the one side, causes the backbone to bend. School-children, from a carelessness in sitting or standing, or from badly constructed desks, are also liable to this deformity. Remember, therefore, to carry the baby, or the bucket, or the coal, first with one arm and then with the other."

MORE DEFORMITIES.

As the doctor entered the study next day he chanced to look through the window into the road.

At the same moment a cyclist turned the corner, and came riding towards the house.

"Look, boys," said he, "here is another illustra-

Hurtful Posture in Cycling.

tion of how our young folks deform themselves. See where that youth's chin is—nearly resting upon the handle-bar. Cycling is a healthy pastime, and no one is fonder of the exercise than I am; but to

ride in such a position as that is most ridiculous, to say the least, and is apt to produce deformity of the spine and chest."

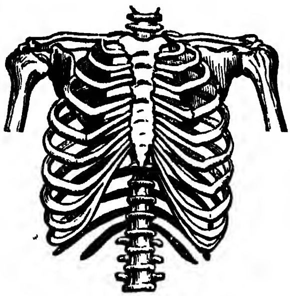
When seated once more round the table, the doctor proceeded to speak about a deformity which not infrequently occurs in women, and which is wilfully inflicted by themselves.

"The ribs," he said, "play a most important part in breathing; and free and easy breathing is most essential to a healthy existence. Hence if we do anything that will in any way interfere with the breathing movements, we are really endangering our health. I remember a very sad case which happened here a few years ago which showed the effect of extreme pressure upon the chest. A new drain was being laid through the High Street, and one day, whilst the navvies were busy digging out the trench, a quantity of earth from the sides fell in. One poor fellow before he could be got out, although his head and mouth were uncovered, died from suffocation, because the pressure of the earth on his ribs had prevented him from breathing.

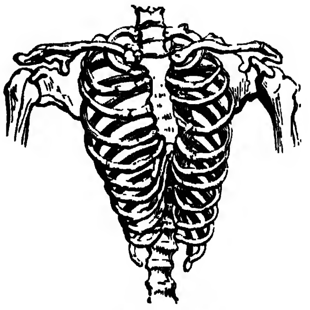
"In order that we may breathe freely our clothes should never press tightly on the ribs and waist. I have an instrument by which I can tell how much air is drawn into the body at each deep breath; and I find that when a man is undressed he can take in about one-third more air than he can with his clothes on. Now men's clothing is not very

tight; and if it interferes with their breathing to this extent, how much more serious must be the interference in the case of women whose clothing around the waist is unduly tight.

"This, however, is not the whole of the mischief caused by tight-lacing, as it is called. When the



Natural Waist.



Unnatural Waist.

pressure is placed upon the soft ribs of growing girls, not only are the ribs prevented from moving or expanding, but they are forced inwards so much that the chest becomes actually deformed."

Here the doctor showed his pupils a picture of the ribs of two young women; the one with a waist as it should be, and the other with one as it should not be. With the unnatural waist the amount of breathing-room is seen to be greatly reduced; and such organs as the heart, stomach, and liver are seriously injured by the pressure of the lower ribs.

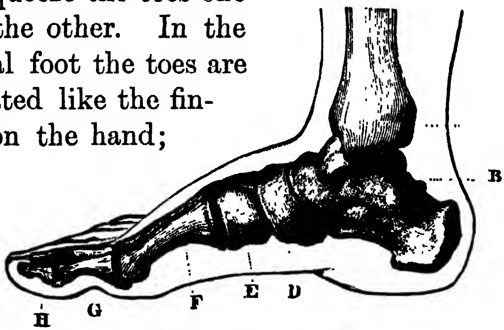
As soon as her father had finished explaining about the picture, Ethel said that "she felt sure

that the women did not know how much they were hurting themselves by tight-lacing or they would not do it".

"That may be true in many instances," said her father, "but there are many who are fully aware of the dangers, and yet continue to pinch themselves because it is 'fashionable', as they say."

ANOTHER FASHIONABLE DEFORMITY.

"The last point I wish to tell you about," continued the doctor next day, "is never to wear tight boots; they press the foot into an unnatural shape, and squeeze the toes one over the other. In the natural foot the toes are separated like the fingers on the hand;



Bones of the Foot, from the side.

A, Tibia; B, astragalus; C, os calcis; D and E, other tarsal bones; F, metatarsal bone of great toe; G and H, phalanges of great toe.

but I am afraid that very few natural feet are to be found nowadays.

"If we examine the bones of a foot we see they are arranged like the arch of a bridge, the pillars of

the arch being at the heel and at the balls of the toes. It is the arch of the foot which makes the tread light and springy."

At this point the doctor removed Harry's boots and lashed a piece of flat wood to each foot. When Harry tried to walk in his "new boots", everyone

The normal human foot and the bad shape of boot often worn.

Foot deformed by badly-shaped boot.

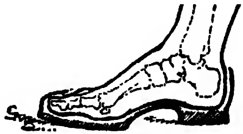
Foot of Chinese lady deformed by boot.

burst out laughing, for it was so comical to see how awkwardly he moved about.

"From that experiment," the doctor went on to say, "you see how difficult it would be to walk if we had flat feet. Now by wearing boots with high heels the natural arch of the human foot is broken down; and instead of walking with a graceful step, we simply hobble along.

"But if our boots have pointed toes as well, then the feet are still further crippled. The great toe is thrust inward, and the little ones have to find

room as best they can. This they generally do by overlapping one another. The most hideous form of foot, however, is to be found among the Chinese ladies. Large feet are considered by them to be very ugly, and it is the practice of Chinese mothers to bandage the feet of their children so tightly that they are actually made too small to walk with."



Shoe-heels should be low and broad and well under the heel — to support the weight.

Never thus — which throws all the weight on to the toes

Shoe of Chinese Lady — actual size is only as large as a baby's shoe!

When the doctor showed his pupils a sketch he had drawn of the foot of a Chinese lady, they wondered, as well they might, how the women managed to get about at all.

"Among the lesser injuries caused by ill-fitting boots are *corns* and *bunions*. You all know how sore a blister is when the outer skin has been broken or removed. Now wherever any pressure or friction occurs the outer skin gradually increases in thickness, as may be seen in the horny hands of a labourer or in the palm of the carpenter thickened from using the chisel. The skin of the feet is

affected in a similar way by wearing tight boots, and if the pressure be continued, the hard skin, as we call it, is forced into the sensitive parts beneath, and we have a *corn.* Bunions form at the joints of the foot, especially in the great toe. The pointed boots alter the joints to such an extent that they become enlarged, and form a bunion.

"Now before you go out to play I want you to promise me to perform a little experiment before you go to bed to-night. Harry is to take off his boots and stockings, and to stand upon a sheet of white paper. Arthur will then carefully mark the outline of Harry's feet with a lead-pencil. When that is done compare the drawing with the boots he is now wearing, and you will be surprised at the difference between the two."

THE COVERING OF THE HOUSE I LIVE IN.

"Now, Arthur," said his uncle, after dinner next day, "before we begin a new lesson let me see the drawing you made of Harry's foot last evening."

Arthur did as he was told immediately.

"Did you compare the drawing with his boot?"

"Yes, uncle," said Arthur; "and his foot when standing was wider than his boot."

"You see that even Harry's boot, which cannot be said to be tight, does not allow for the spreading

out of the foot when he stands; so that you can easily understand how terribly the feet must be pinched by the 'fashionable' boot, as it is commonly made. We must not, however, dwell any longer upon these 'instruments of torture', but get to work with our next lesson.

"So far," continued the doctor, "we have been talking chiefly about the inside of the body. To-day we shall examine the outside of it alone.

"Do you know what the natural covering of the body is called, Harry?"

"The *skin*," answered Harry promptly.

"That is quite right. The clothes we wear are known as our artificial covering; but the skin is the natural one.

"Although it is usual to speak about the skin as if it were only one layer, yet there are really two skins—an outer and an inner one.

"The outer skin has neither nerves nor blood-vessels in it. This I can easily prove to you, because after our lesson yesterday I was unfortunate enough to scald my hand slightly and raise a blister.

"With my sharp penknife I will cut the blister right across, and you see I show no sign of suffering pain. That is not because I am trying to deceive you, but simply because there is really no pain to be felt. Had there been any nerves in the outside skin I should have felt a pain the instant my knife touched the blister.

"When Ethel runs her sewing-needle into her finger a drop of blood oozes out at once; but you see no blood comes from this outer skin when I cut it, because it has none of those tubes which hold the blood, called blood-vessels. On the other hand, if my knife were to penetrate the least distance into the under skin, the blood would instantly flow, and a sharp pain would be felt. Both blood-vessels and nerves are found in the under skin, and they are packed together so closely that you cannot stick a needle into any part of it without piercing a blood-vessel or touching a nerve.

"To doctors the under skin is known as the *dermis* or true skin; and because the outer skin rests upon the dermis it is called the *epidermis* (*epi* being the Greek word meaning over). The dermis is the thicker of the two.

"Although the epidermis is not sensitive, and does not bleed, you must not think that it serves no useful purpose. If it were to be entirely removed from the body, life would certainly not be worth living. It would be impossible to stand, or sit down, or touch anything without suffering severe pain. This you will readily understand when you remember how painful it is to touch the knee when you have fallen down, and just grazed it sufficiently to remove the outer skin."

"I do," said Ethel, "for I had a taste of it yesterday, when running along the garden path."

"Not only does the epidermis protect the dermis from injury, but it also has the power of absorbing water or any substance which may be rubbed over Castaways have been saved from death by thirst, by remaining for some time in sea-water; and, in the case of people who are very ill, cod-liver oil is sometimes rubbed into the skin when the patient cannot take it otherwise.

Structure of the Skin.

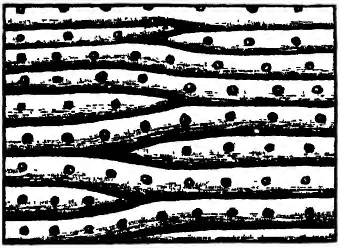
"If we examine the palm of the hand with the naked eye, or, better still, with a magnifying glass, the epidermis will be seen to be thrown up into little ridges with tiny channels running on each side of them. All along the tops of the ridges are a number of exceedingly small openings called *pores*, which are the mouths of certain tubes running into the dermis.

At this point the doctor brought out his microscope, and placed under it a very thin slice of the skin from the palm of the hand. After each of his pupils had had a peep at the skin, he next showed them a picture which he had drawn of what they had been looking at.

"That is exactly like the view in the microscope," said Arthur; "but is there any special reason for

the pores being at the tops of the ridges and not in the channels?"

"Oh, yes," said the doctor; "and here is another example of the wonderful foresight of our all-wise Creator. If I were to give any of you a coat of varnish or enamel, and thus close up the pores, you would soon die of poisoning; because the skin would be no longer able to get rid of the foul matters in the blood. So you see how very important it is that the pores should always be open.



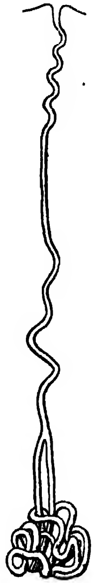
Surface of the Skin magnified, showing pores.

"Now if any substance were to lodge for a time on the top of a ridge, it would soon be rubbed away by the movements of the body against the clothing or other objects. The skin, moreover, on these ridges is made of very minute scales, which are constantly peeling off. Every day and every hour some of these scales are crumbling away from the surface of the body. So that, in this way, the pores are kept open and the work of the skin is not interfered with unless we are exceptionally dirty."

THE GLANDS OF THE SKIN.

When the doctor met his pupils again, he proceeded to tell them more about the skin, and of the great importance of keeping it clean by the free use of soap and water.

"The pores I spoke about in our last gossip", he continued, "are the mouths of tiny tubes called *sweat glands*. Each gland passes through the epidermis into the dermis, where it ends in a little coil like a tiny ball of string."



A Sweat Gland, highly magnified.

Here the doctor pointed out the ending of one of these glands on a large diagram which he had specially drawn for the lesson.

"These glands are so minute that it requires a strong microscope to see them; but to make up, as it were, for their smallness, there are millions of them in the skin."

The doctor then took a piece of chalk, and after drawing a square with one-inch sides in the centre of Harry's palm, he asked what was the size of the square so drawn.

"A square inch," said Ethel and Arthur together.

"Now how many sweat glands do you think there are in that square inch?"

Arthur looked at the palm of his hand for the

answer, but not finding it there, confessed that he did not know.

"Well, there are between two and three thousand; and there is about the same number to the square inch in the soles of the feet. In other parts of the body they are not nearly so numerous, and in the back and neck the number is not much more than four hundred to a square inch. Altogether it has been estimated that there are about *three million* sweat glands in the whole body.

"Just before the point at which the sweat gland opens at the surface of the skin, it is generally found to be twisted round and round, as you see in my drawing."

"Just like a corkscrew," said Ethel, trying to have a little fun out of her father's picture.

"Each gland may be considered as a little factory; because it manufactures something from the blood. Closely surrounding the coiled end of each gland is a beautiful network of hair-like blood-vessels. From the blood which these contain, the glands make the fluid which we call *perspiration* and *sweat*."

"Why do you say perspiration *and* sweat?" asked Arthur. "I always thought they were the same."

"So they are in composition," replied his uncle; "but we only use the term 'sweat' when the perspiration can be seen standing like beads of water on the skin. Except when the body is overheated by violent exercise, the water taken from the blood

by these glands passes from the body as perspiration without our noticing it.

"In a state of ordinary health we are always perspiring. Most of the perspiration soaks into our clothing, and it is for this reason that people are recommended to wear woollen material next the skin. If the perspiration remains on the skin, it allows the heat of the body to escape, and a feeling of chilliness follows. Wool, however, absorbs the moisture very readily; cotton and linen only a little. So that by wearing woollen clothing next the skin we avoid the danger of chills after taking exercise."

MORE ABOUT THE GLANDS OF THE SKIN.

On the following day the doctor began his talk by asking his young students how much perspiration they thought passed from the skin each day.

Arthur was very good at riddles, but this question was a puzzle to him.

"If much of the perspiration leaves the body without our noticing it," said Arthur, "how are we to tell how much we lose?"

"Very easily. Instead of letting it escape into the air, we lay a trap for it. By putting an undressed man into a water-tight bag, with openings for breathing, the moisture collects on the inside of the bag; and if the water so obtained be afterwards weighed,

the answer to my question is found. It is about $1\frac{1}{2}$ pounds in twenty-four hours.

"Perspiration is, however, by no means pure water. It is indeed extremely impure, and acts as a poison if allowed to remain in the body. An instance proving the truth of this occurred at Rome many years ago. The body of a little boy was completely covered with gold-leaf, in order that he might take the part of an angel in a show. When bed-time came the little fellow was put to bed with the gold-leaf still upon him; and in the morning, when his mother went to see how her boy looked asleep, she found he was dead. The gold had completely closed all the pores in his skin, and he had been poisoned by the sweat and carbonic acid gas which could not escape. This proves the truth of what I told you yesterday about varnishing the body all over.

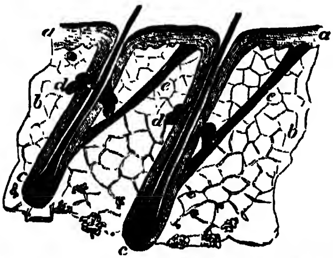
"Besides being a means of removing the foul matters from the body the perspiration serves a further purpose. I have already said that much of the perspiration soaks into our clothing; but a great deal of it *evaporates* and passes into the air. Now to understand the importance of this I am going to perform a simple experiment."

Taking down a bottle of *ether* from one of the shelves, the doctor poured a little of it upon the back of the hand of each of his pupils. Almost instantly the ether had dried up; and when the

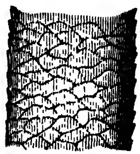
doctor asked how their hands now felt, all three replied that they were cold just where the ether had been.

Arthur also said that he had noticed the same thing when he wetted his hands and dried them by waving them in the air instead of using a towel.

"You are quite right," the doctor went on to say; "both the water and the ether, in evaporating,



Hair, Hair Follicles, and Glands. *a*, **Epidermis;** *b*, **true skin;** *c*, **hair bulb;** *d*, **sebaceous glands;** *e*, **muscle attached to hair sac.**



Hair under the Microscope, showing the cells overlapping like tiles.

robbed the hands of some of their heat, and so produced a feeling of coldness. As soon, therefore, as the perspiration oozes out upon the surface of the skin, it evaporates, and the body is cooled. The hotter the air around us, the more do we perspire; but as fast as the sweat comes out of the pores it evaporates, and thus reduces our temperature. It is in this way that the heat of the body is kept from rising above $98\frac{1}{2}°$ F., which is its temperature in health. In winter time, when the air is cold, less perspiration comes to the surface, and consequently less heat is lost than in summer.

"Were it not for perspiration, it would be impossible for those engaged in certain occupations, such as ironfounding, to withstand the great heat and cold to which they are exposed.

"Besides the sweat glands, there is in the skin a smaller number of oil glands. These are short and branched, and are connected chiefly with the hairs, as shown on the left of my picture. Their work is to draw from the blood an oil which not only serves to moisten the hair, but to soften the skin and render it supple, or bendable, if I may so term it."

"Then that is the reason why we are told not to use any hair-oil or pomatum," said Arthur.

"Exactly; if we keep the skin clean and brush the hair well, nature's own oil is quite sufficient."

THE DEAD RABBIT.

Ethel was the doctor's only child; and it was no wonder he did all in his power to make her as happy as possible. But when one of the doctor's patients sent her a pet rabbit, her delight knew no bounds. Every morning, as soon as the breakfast-table was cleared, she would visit bunny and give him some fresh food.

But alas! There was a terrible blow in store for poor Ethel one morning. When she reached the

hutch as usual, the sight she saw brought the tears thick and fast to her eyes: her pet rabbit was dead.

Everyone did his best to console her, but for a time it was of no avail.

"Cheer up, my little woman," said her father at

last; "it's no use crying over spilt milk. I'll ask Farmer Hodge for another rabbit to-day. Besides, you can have the skin made into a muff for the winter, and bunny will still be of some use."

This made Ethel brighten up a little; but when the doctor went on to say that they would have a chat over bunny's body, she was ready to cry again.

Before leaving the house that morning to visit

his patients, the doctor said he would put off his lesson till the morrow; for he knew quite well that Ethel would be too full of her troubles to pay much attention to what he might say. So the pet rabbit was wrapped up in a clean sheet of paper, and placed on the table in the scullery.

Next day the lesson was held in the kitchen; and by this time Ethel had quite got over her trouble. The rabbit was brought out and put on the table, and the doctor began his chat by calling the attention of his pupils to bunny's coat.

"What lovely fur it has!" said Harry, "and how thick!"

"There would not be much fear of bunny being cold with such a covering, would there?" asked the doctor.

"I should think not," said Harry.

"When I take off the skin from the rabbit," continued the doctor, "the fur will come with it, because the fur grows from the skin just as the hairs do from our skin.

"And when the skin is off, what do you expect to see underneath?" the doctor asked.

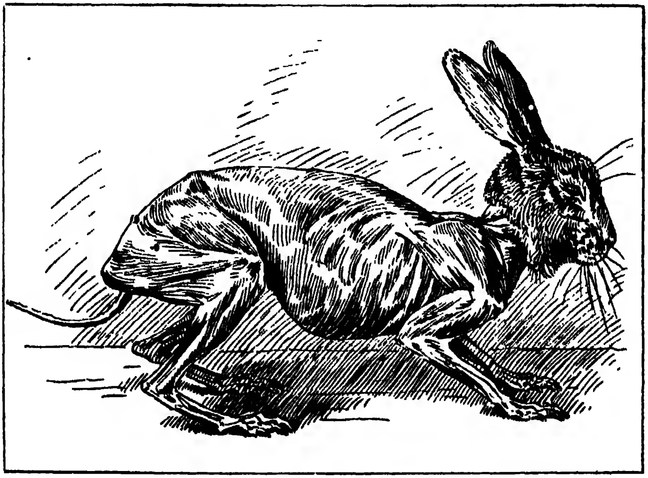
"The flesh," replied Arthur.

At this point there was a pause in the lesson until the doctor had completely removed the rabbit's skin.

"Everywhere in the rabbit's body," the doctor went on, "the bones are covered with flesh, or *muscle*, as it is properly called; and if the human

skin were to be removed in the same way, the human muscles would be brought to view.

"The red colour of muscle is chiefly due to the



A Rabbit, with skin removed from the body, showing the Muscles.

blood which it contains. This you may prove for yourselves; and I will finish the lesson by telling you what to do. Ask your aunt for a piece of raw meat, and then wash it thoroughly under the tap. You can bring the meat with you to-morrow for me to look at."

HOW THE MUSCLES WORK.

When the time for the lesson arrived next day, the piece of meat which Arthur had begged from

his aunt had been so thoroughly washed that not a trace of blood was left in it. What was once a piece of red juicy flesh was now simply a mass of whitish-looking strings.

Portion of a Voluntary Muscle—showing its plan of structure. *a*, Striated muscular fibres. *b*, Ultimate fibrillæ. *c*, Ends of the fibres.

A highly magnified view of a fibre of Striped Muscular Tissue, with its inclosing sheath of *Sarcolemma*. In this case the fibre has been torn, and the torn ends separated, but the delicate and elastic sheath still stretches between them.

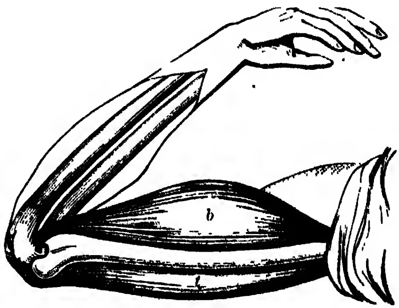
"You have succeeded very well with your experiment," began the doctor, after he had examined the meat. "By washing the meat, as you have done, its appearance is entirely altered. All the blood has been removed, and only a whitish, stringy mass is left.

"By placing a thin slice of muscle under the microscope, we can learn still more about its structure. Every muscle will be seen to be made up of a great number of very fine threads or *fibres* lying side by side like sticks in a bundle. These fibres are bound together into little bundles; a number of which are again similarly bound together to make a larger bundle; and several of these larger bundles make a muscle.

"Some of the muscles are fastened immediately

to the bones, and grow, as it were, into them. Usually, however, the ends of a muscle first of all change into white cords called *leaders* or *tendons*, which are fixed to the bones.

"How the muscles work will be best understood by studying the one which lies in front of the upper arm. It is known as the *biceps muscle.* By means of two tendons, one end of this muscle is fixed to the shoulder, and by another tendon the other end is fastened to one of the bones of the forearm.



Biceps and Triceps Muscles.

This figure shows the Biceps Muscle (*b*) contracting so as to draw up the arm. When the arm is again straightened the Triceps (*t*) has a swollen appearance, because it has contracted and become thicker.

"Now, if I wish to bend my arm, I can only do so by the aid of this muscle. All the fibres of which it is made have the power of shrinking or *contracting*, as it is called, just as a piece of rope does when wetted. Unlike the rope, however, as the muscle contracts, it grows thicker principally in the middle; while the rope swells equally all the way along."

"Then that is the reason why a big lump rises under the skin, when I bend my arm," said Arthur.

"That is the reason," said his uncle; "when a muscle contracts it gets *shorter and thicker*.

"Now, when the biceps muscle contracts, it must move one of the bones to which it is fixed; otherwise, the muscle would tear away from the bone the moment it began to contract. We know, however, that the forearm moves at the elbow, like a door on its hinges; and this movement takes place each time the muscle contracts. Acting in a similar manner upon all the bones of the body there are in all about four hundred muscles."

When the young folks were dismissed, it was not long before they were exercising the majority of their own muscles by their games in the meadow.

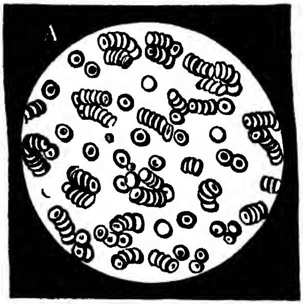
THE RIVER OF LIFE.

When the doctor met his pupils again he remarked that, having spoken of the blood on several occasions, he would now give them some more definite information about it.

"The blood system in the body", he said, "has been beautifully called 'the river of life'. At first it may seem strange to speak of the blood as a river; but in several respects the flow of the blood and the flow of a river are very much alike. The blood like the river is always flowing, and always in the same

direction; and it keeps its own course—in the blood-vessels—like the river in its channel.

"And just as a river carries bits of wood, straw, and leaves, together with many substances in solution, through the country in which it flows,



A Drop of Blood as seen under the microscope.

Red Corpuscles of Blood magnified.
A, Seen in face, B, the same seen edgewise.

so does the blood carry thousands—I might say millions—of tiny particles through the body in addition to a host of materials dissolved in it."

"I am sure," said Arthur, "when I have cut myself sometimes, and have bled, I have never seen any of the millions of particles you speak about."

"That is because they are too small to be seen by the naked eye; they are only visible when looked at through a good microscope. Here let me show you them."

The microscope was at once brought out, and the doctor twisted a piece of string pretty tightly round the end of the middle finger of his left hand, and

made a slight prick with a sharp clean needle. A drop of blood immediately oozed out. This he placed on a clean strip of glass, and covered lightly with another piece of very thin glass, so as to spread it out evenly in a thin layer. Then the glass slip was put under the microscope, and each of the pupils looked at it in turn.

Arthur could scarcely believe that what he now saw was the drop of blood which came from his uncle's finger.

"It does not look like blood at all," he said. "There is nothing but a large number of reddish round things."

"Just like tiny biscuits," added Ethel.

"The reddish round things, as you call them, are not the only things there. If I tilt the microscope a little, Ethel's 'biscuits' will be seen floating in an invisible something. This something is the watery part of the blood. Moreover, if you look very carefully, one or two of the little bodies will be found to be colourless. These tiny red and white bodies are known as *corpuscles.* So that we can say that blood is made of three parts:—(1) the blood fluid, (2) the red corpuscles, and (3) the white corpuscles.

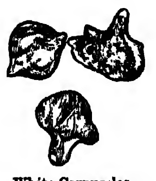
"The total quantity of blood in the body is about fifteen pounds, of which the greater part is water. In a half-pint, that is ten ounces of blood, there are about eight ounces of water. It is the red corpuscles which make the blood look red.

"The red corpuscles are so very small that the width of three thousand of them would not measure an inch; or, if we were to place them in a pile, as the bank-teller places the sovereigns, we should have to put 1,400,000 corpuscles one upon the other before they would reach an inch in height.

"Although the corpuscles are such tiny workmen, yet their work is of the utmost importance to us. All day long, and all night too, they carry oxygen from the air to every part of the body."

The doctor did not stay to explain the nature of oxygen. He knew his nephews had learned at school that it was a gas to be found in the air we breathe and in the water we drink.

"The white corpuscles are slightly larger than the red ones, but are not nearly so numerous. As we watch them through the microscope, rolling and tumbling about in the clear liquid, we shall see that they are continually changing their shape. One moment they are like a ball, the next they are pear-shaped, then perhaps square or else three-sided.



White Corpuscles.

"And now I think it is time we stopped, or we shall have your red corpuscles crying out that they are not getting enough oxygen to keep your brains alive and at work properly. So out you go into the fields."

HOW "THE RIVER OF LIFE" IS KEPT MOVING.

When Ethel answered the butcher-boy's call next morning, she found that a sheep's heart had been sent with the joint of meat. She guessed at once what her father wanted it for, and ran off to tell the boys, who were busy weeding in the garden.

Sheep's Heart, after removal from body.

Dinner over, the doctor called the young folks to his study. "Yesterday, I pointed out", he said, "that the blood was flowing through the body like a river. I must now tell you how this constant flow is kept up."

"By the heart," said Harry, prompted by the presence of the sheep's heart upon the table.

"Yes, it is the heart. Every time you feel the heart beat—you can feel the beating by placing the hand on the chest—the blood is pushed, as it were, along the blood-vessels. Before you can properly understand this, however, I must say something about the heart itself.

"In appearance, the human heart is very much like this sheep's heart, and is about the size of the closed fist of the person to whom it belongs. Thus my heart is about the size of my fist, and a baby's heart is about the size of its little fist. The

Fig. 1

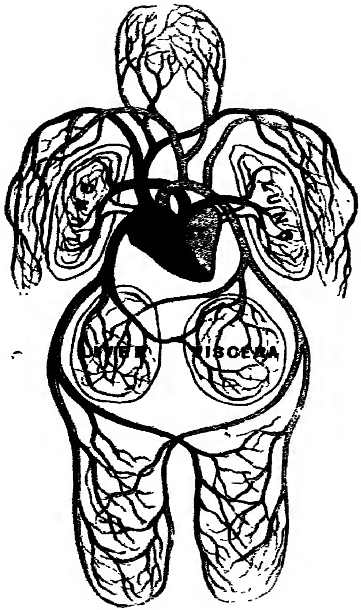
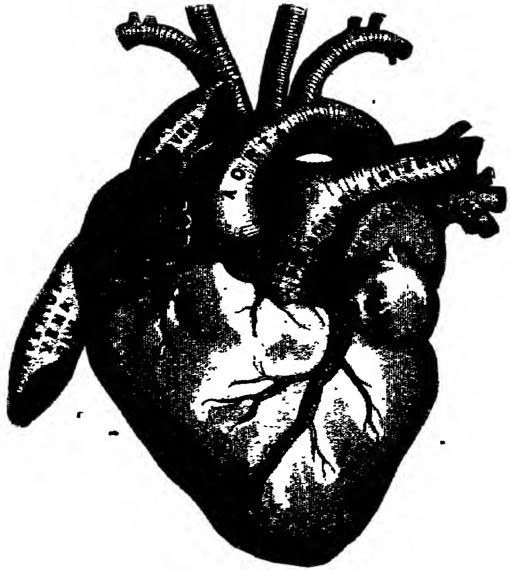
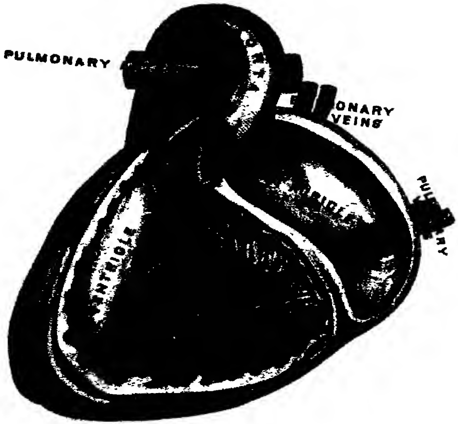


DIAGRAM SHOWING THE CIRCULATION OF THE BLOOD



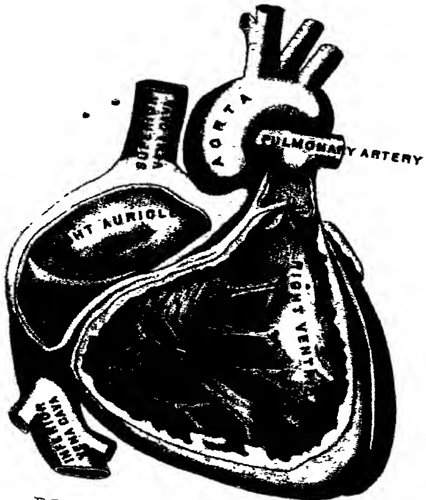
EXTERNAL VIEW OF HEART FROM FRONT

Fig. C



LEFT SECTION OF HEART.

Fig. D

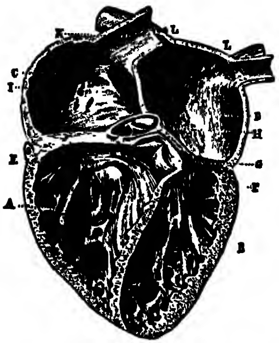


RIGHT SECTION OF HEART

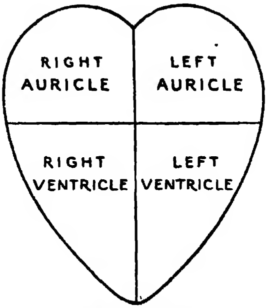
flesh or muscle of the heart has the finest grain of any in the body."

At this point the doctor cut the sheep's heart into halves and showed the four chambers within it.

"In the human heart," he continued, "we have



The Human Heart (mammal) opened to show the four chambers



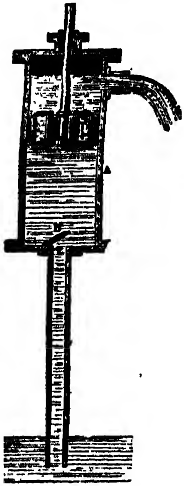
Diagrammatic Form.

also four similar chambers. It is like a four-roomed house, two rooms upstairs and two rooms downstairs; or perhaps it would be better to say it is like two houses of two rooms each. For just as the brick wall separates the two houses, so does a thick wall of flesh separate one side of the heart from the other. Any blood that may be in the rooms on one side of the heart cannot pass through the partition into the rooms on the other side.

"The upper rooms of the heart are called *auricles*; the lower ones *ventricles*. So that we have a right and left auricle, and a right and left ventricle. The

walls of the ventricles are thicker and stronger than those of the auricles, and those of the left ventricle are stouter than those of the right ventricle.

"Between an auricle and a ventricle there is a sort of trap-door, or *valve*, as it is *called, because it allows the blood to flow through it in one particular direction only.*"



Common Pump.
B, The valve opening into the barrel A.

"We were shown at school how a valve worked," said Arthur, "when the lesson was on the common pump. The valve would only let the water pass upwards into the barrel, and when it was full the valve closed and stopped the water from going back into the well."

"Exactly. But you must remember that the valves of the heart open downward into the ventricle and not, like the pump-valve, upward into the barrel. Each valve is formed of thin, three-sided flaps of tough skin or *membrane*. The valve in the right side of the heart has three such flaps, the one in the left side only two.

"While the blood is flowing from an auricle to a ventricle, the flaps lie down against the sides of the heart; but as the ventricles fill they float upon the surface of the blood until they meet and so close the passage between the two sets of rooms.

Now perhaps you wonder why the valves are not forced right up into the auricles. If you will look at the sheep's heart you will see how beautifully this is prevented. The edges of the flaps are fastened to the walls of the ventricles by a number of fine threads or tendons which are only just long enough to allow the valves to close together. But since these threads will not stretch, you can see that the more the blood pushes against the valves the tighter they become, and the closer the flaps come together, till at last the passage is completely blocked up."

"These threads remind me of the ribs in my umbrella," said Ethel as she rose from the table at the conclusion of the lesson.

THE JOURNEY OF THE RIVER OF LIFE.

Next day the doctor proposed that his class should take an excursion with him to the waterworks of a neighbouring town. Of course the idea of a change pleased the young folks very much, although they guessed the doctor would use the waterworks to teach them something, but in what way was not very clear to them.

As they passed through the pumping-house, the engineer explained to them that the water was obtained from an artesian well about 900 feet deep,

and that at each stroke of the pump 300 gallons of water were poured into the main leading to the reservoir where the water was stored.

From the pumping-house the engineer took them to see the reservoir, and he pointed out how the water was carried thence to the town for the use of the inhabitants.

When they returned from the waterworks the doctor repeated all that they had been told; explaining once more how the pump forced the water into the reservoir, and how the water was distributed to the people who wanted it.

"In our body," he continued, "the blood is distributed in a similar manner. The pumping-house is represented by the left side of the heart. As soon as the left ventricle is full of blood the muscles in its walls squeeze together suddenly and drive the blood out at once into a big pipe called an *artery*. This artery is the largest in the body, and is known as the *aorta*. It is about an inch across and has thick and strong walls. At each squeeze or 'beat' of the heart about four or five ounces of blood are forced into the aorta; and just as the great main which leaves the waterworks sends off branches along the various streets in the town, and these again send smaller pipes into the houses, so it is with the aorta and its branches. One branch of the aorta goes to the right shoulder, another to the left; two more branches carry the

blood to the head, whilst other branches distribute blood to the remaining parts of the body.

"When the blood has visited every portion of the body it is brought back again to the heart by another set of pipes called *veins*. Here I can give you another illustration. To carry off the waste water from each house we have the drains. These drains pour their contents into the pipes in the streets called sewer-pipes, and these again flow into one immense main sewer which carries the unwholesome water away from the town. The *veins* form, in a sense, a similar drainage system for the body. They commence in very minute tubes, and then gradually unite into larger and larger vessels until they form the two great veins which open into the right auricle of the heart.

"Before we leave our illustrations we can make a further use of them. When the water leaves the reservoir by the great main it runs with much greater force and rapidity through the pipes than it does when it is afterwards running off through the drains. So does the blood, propelled by the heart, flow with greater force and rapidity through the arteries than the same blood afterwards flows through the veins.

"The last point I shall explain to-day is how the blood passes from the arteries to the veins. It was Doctor William Harvey who, nearly three hundred years ago, first discovered that the blood actually

moved in the body. By means of the microscope he saw the blood flowing along one set of tubes and returning along another set; but he never discovered how the blood passed from the one to the other. When Harvey had been dead several years, more powerful microscopes were invented; it was then found that the finest branch of every artery broke up into a network of very fine tubes or *capillaries*, and that these were again united to the finest veins.

Network of Capillaries connecting Artery and Vein.

"So that the blood, after leaving the left ventricle, flows along the aorta into the smaller arteries which go to the head, arms, legs, &c. From these smaller arteries it goes to the capillaries, from the capillaries to many veins, and from the many veins into two large veins which open into the right auricle of the heart.

"I have not quite completed the whole of the journey of the blood, but the rest I must leave for another lesson."

A WONDERFUL SIGHT.

"Yesterday", continued the doctor, "I explained to you how the blood passed from the left ventricle to the right auricle by way of the arteries, capillaries, and veins.

"Before I complete the journey of the blood, I must tell you about the change it undergoes whilst flowing through the capillaries. In the aorta and its branches the blood is bright red and full of oxygen; but as it slowly flows through the capillaries, its oxygen is given up to those parts of the body in which the capillaries lie, and at the same time receives back in exchange several impurities. The result of this is, that the good blood from the arteries is made impure, and is now no longer of a bright-red colour, but dark-blue or purple. So that the blood poured into the right side of the heart is of a different colour to that poured into the left side.

"It is, however, only allowed to remain impure for a short time. From the right auricle it passes at once to the right ventricle; and when this chamber is quite full, its muscles squeeze or contract, like those of its neighbour on the left, and the blood is forced through another big pipe called the lung artery. This artery divides into two smaller branches—one goes to the right lung, and the other goes to the left lung. These two in their turn

divide and subdivide until they are of the size of capillaries. Whilst the blood is flowing through the lungs another exchange takes place. The blood gives up its impurities, and absorbs a large amount of oxygen which has been obtained by the lungs from the air. This restores the red colour of the blood again, and makes it fit to continue its work of keeping all the organs of the body alive and strong.

"Let me read to you the beautiful lines which Oliver Wendell Holmes, the American poet, has written about the changes I have just described:—

"'The smooth, soft air, with pulse-like waves,
Flows murmuring through its hidden caves,
Whose streams of brightening purple rush,
Fired with a new and livelier blush;
While all their burden of decay
The ebbing current steals away,
And, red from Nature's flame, they start
From the warm fountains of the heart.

"'No rest that throbbing slave may ask,
For ever quivering o'er his task,
While far and wide a crimson jet
Leaps forth to fill the woven net,
Which in unnumber'd crossing tides
The flood of burning life divides;
Then, kindling each decaying part,
Creeps back to find the throbbing heart.'

"To enable the blood to reach the 'throbbing heart', the capillaries of the lungs unite into four

veins—two for each lung; and these bring back the bright scarlet blood to the left auricle of the heart, from whence it started. No sooner has it arrived there than it starts again on its journey round the body, such as I have described. This continued movement is known as the *circulation of the blood.*"

At this point the doctor asked to be excused for a moment, whilst he fetched a little friend from his cucumber-frame to finish the lesson for him. At this remark the young students laughed outright, for they could not imagine who could be in the frame that could take the doctor's place.

Their curiosity was quickly satisfied by the return of the doctor with a live frog in his hand.

"Here is the little chap that shall finish the lesson to-day. I have often heard your father say that 'a yard of seeing was worth a mile of hearing'; and so far you have only my word that the blood does circulate in the body. Now you shall see it for yourselves."

With that the doctor proceeded to place the foot of the frog under the microscope. The web of the foot is formed of very thin skin, and is so clear and transparent that you can see through it quite easily with a powerful instrument. What the pupils saw was a large number of minute tubes with delicate walls, and the blood flying rapidly along them. They could see the corpuscles pursuing and tumbling over each other in a marvellous manner. No

wonder Arthur exclaimed that it was the most wonderful sight he had ever seen.

A CHAPTER OF ACCIDENTS.

The following day proved to be a busy one for the doctor. In the first place, whilst the family were at dinner, he told them that as he was making his usual round of calls in the village, he was called to see Polly Perkins, who had been suddenly taken ill in the next street.

"When I reached the spot," he continued, "I was glad to find that they had laid her flat on the pavement, instead of setting her bolt upright, as some folks would have done. She was quite pale, and her skin cold; even her lips looked bloodless. These symptoms, together with the feebleness of her pulse, satisfied me that she had only fainted."

"What do you think was the cause of her fainting, father?" asked Ethel.

"Very likely fright; or perhaps she had been eating something which had disagreed with her; but I am half inclined to believe that it was due to tight-lacing as much as anything. I have warned her several times already.

"What annoys me most is the silly practice which people have of crowding round a person in a

fit. The fresh air which the patient needs most is in this way denied her. However, after making the on-lookers stand aside, and having loosened her dress round her neck, I bathed her forehead with some cold water, and in a short time she was all right again."

Scarcely had the doctor finished the last sentence, when a violent ring was heard at the surgery-door. The next moment the servant brought a message to the doctor to the effect that he was wanted at the station; a gentleman had died suddenly whilst running to catch his train.

The doctor was quickly upon the scene, but unfortunately his services were of no avail; the gentleman was beyond all human aid. In answer to the numerous questions on his return to the house, the doctor explained that it was a case of a weak heart.

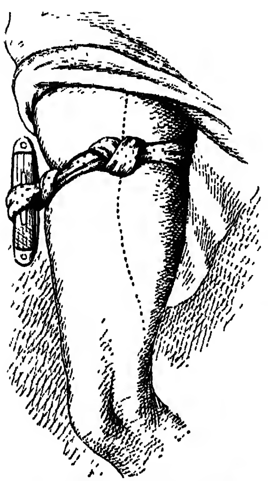
"Probably", said he, "the valves did not open and shut perfectly; and when such is the case it is very dangerous for anyone to run to catch a train, or to go quickly up a hill or a flight of stairs.

"Then, just as I was passing Farmer Onslow's field, I had to run to the assistance of one of the reapers; the poor fellow had cut an artery in his leg with a scythe, and the blood was flowing freely from the wound.

"But how did I know that an artery had been cut?" asked the doctor.

"Because the blood was scarlet," answered Arthur promptly.

"Yes; and because the blood came out in jerks. Had it been a vein, the blood would have trickled out in a continuous stream, and would have been of a dark-purple colour; and since I think that everyone should know how to act in case of such accidents, I will tell you what I did to stop the bleeding.



Arrest of Bleeding from Foot or Leg by knotted handkerchief twisted by means of a pocket knife, the knot pressing in the proper place.

"First of all I had the man placed flat on his back; and as I was convinced that he had severed an artery, I knew that the blood was flowing from the heart towards the cut. Taking out my handkerchief, I tied a firm knot in the middle of it, and placed the knot just above the cut; that is, on the side nearer the heart. After binding my handkerchief tightly round his leg, I passed my penknife between it and the leg on the side opposite the cut. By twisting the penknife round and round several times, I made the hard knot press so firmly upon the artery as to close it, and in this way stopped the bleeding. Of course, all this was done in a shorter time than it takes me to tell you. Well,

after closing the wound, I had the patient carried carefully home so as to rest the limb, and to give the cut parts a chance to heal.

"Before I go to see how he is progressing, I should like to ask you one question more. Suppose a vein had been severed instead of an artery; where should I have placed the knotted handkerchief?"

"I know, father," said Ethel; "you would have put it below the cut."

"Quite right," said her father; and with that he walked off to see his new patient.

HOW THE BLOOD IS PURIFIED.

"The other day", began the doctor at the next meeting, "we learned that arterial blood is bright scarlet, while venous blood is dark blue or purple; but from what I said at the close of the lesson you will see that there is an important exception to this rule in the case of the lungs. The arterial blood which these organs receive is like venous blood in appearance. You will remember that the blood from every part of the body, except the lungs, is brought by veins to the right side of the heart, from which it is afterwards sent through the arteries that lead to the lungs. This explains why the blood in the lung arteries is purple instead of scarlet. Lastly, I told you that after circulating

through the lungs, the blood returned to the heart again scarlet in colour.

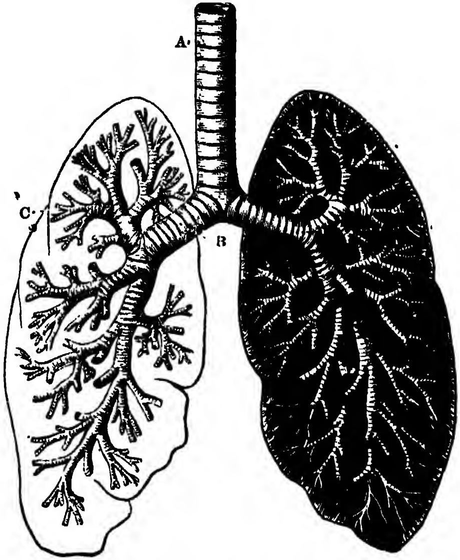
"Now, this change of colour within the lungs is brought about by the means of air. But how does the air get into the body?"

"By breathing," said Harry, in a moment.

"Exactly! Every time we breathe, we take into our lungs as much air as would fill a pint measure. The two lungs are contained in the chest or upper story of the body, and fill nearly the whole of it, leaving but a small space for the heart between them. You have seen the lungs of a sheep hanging up in the butcher's shop. They are called by the butcher *lights*. Well, we may compare the lungs to a pair of bellows. Air is drawn in and then sent out from them about fourteen or fifteen times every minute in the case of an adult, and at a still greater rate in children; and this is continued, whether standing or sitting, sleeping or waking, as long as we live.

"To reach the lungs, the air we breathe has to pass down the windpipe. This pipe is wonderfully made. Running nearly right round it are a number of strong rings of gristle, broad in front and narrow behind, and connected together by numerous muscular fibres. By means of these rings the windpipe is always kept open; otherwise, that is if the sides of the pipe could fall together, no air would be able to enter the lungs, and we should die of suffocation.

"When the windpipe has gone some distance into the chest, it divides into two tubes called *bronchi*, one of which goes to the right lung, the other branching off to the left lung. Within the



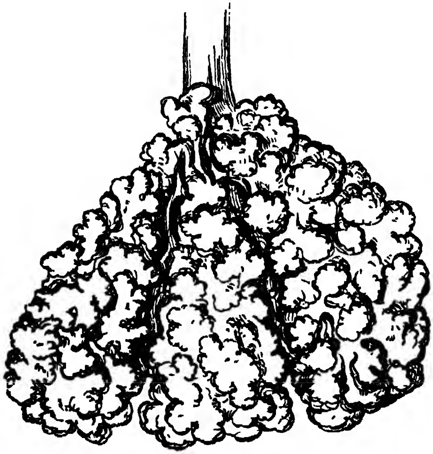
Section showing the ramifications of the Bronchi in the Lungs. A, Windpipe or trachea; B, Bronchi; C, Bronchial tubes.

lung, each *bronchus* divides and subdivides until we have thousands of little pipes called *bronchial tubes.*"

"It must be something like a tree, then," said Arthur.

"That is a very good illustration. The trunk of the tree is the windpipe; the main boughs are

the bronchi; whilst the smaller branches and twigs represent the bronchial tubes. There is, however, one important difference between the two. When the bronchial tubes have become very minute, each ends in a delicate bag, called an *air-cell.* There are, it is estimated, about six million air-cells in the two lungs.



Lung-sacs and Bronchial Tube.

"Each air-cell is closely surrounded by the capillaries of the lungs, much in the same way as a child's india-rubber ball is sometimes covered with a network of worsted.

"Every time we draw our breath, therefore, the air travels down the windpipe till it reaches the two bronchi. Here, some of the air will pass along the left bronchus to the left lung, and some will go through the other bronchus to the right lung. Once in the lungs, the air is conveyed by the bronchial tubes to all the air-cells which are waiting to receive it.

"And now a wonderful thing happens. The

oxygen from the air passes through the thin walls of the air-cells into the blood—that is, into the capillaries which surround the air-cells. As this oxygen goes into the blood from the air-cells, carbonic acid gas at the same time passes from the blood into the air-cells. This gain of oxygen and loss of carbonic acid gas makes the blood once more pure and bright. The lungs, in fact, might be compared to a market-place where two merchants—the blood and the air—meet to transact business in the shape of an exchange. The air offers its oxygen to the blood, while the blood offers to the air in exchange its carbonic acid gas and other waste matters; and this exchange goes on, as I have already said, about fourteen or fifteen times every minute we live."

THE AIR WE BREATHE.

As a good way of introducing the next lesson, the doctor reminded Arthur of the lectures on oxygen he had had at school.

"Oh yes!" said Arthur; "I remember it very well. Of all the lessons I have had in school, I think those about oxygen were the most interesting. They were full of experiments. After pointing out that oxygen was a colourless, transparent, and odourless gas, our teacher showed us that it would

not itself burn, but that it kept other things burning.

"That's the way to remember your lesson, my boy," said his uncle; "but were you told how much of the air we breathe was oxygen?"

"About one-fifth," said Arthur; "and most of

The Effects of Oxygen and Nitrogen on a Smouldering Match.

the other four-fifths was another gas which we were told was called *nitrogen.* I think the teacher spoke of it as 'a sleeping partner', because it prevented the oxygen from being too active and quickly burning up everything."

"That is quite correct," said the doctor, delighted with his nephew's answer. "But since Ethel and Harry have not been so favoured as you have been, I have prepared a jar of oxygen, and another jar of nitrogen, for their benefit.

"Now, Harry, which is the jar of oxygen?" asked the doctor.

But this was a question which Harry could not

answer; for both the gases were both colourless and transparent, and therefore invisible.

"The answer to my question can only be found out by the old way of experiment."

Here the doctor placed a smouldering match first in the mouth of one jar, and then in the other. When the match was put into the jar of oxygen, it burst into a flame; but was extinguished when it was afterwards plunged into the nitrogen.

"To show you the proportions in which the nitrogen and the oxygen exist in air, I will perform another simple experiment," said the doctor.


Phosphorus Burning in Oxygen.

He then placed a small dry piece of phosphorus in a little porcelain dish, floating on some water in a deep basin. Over this he placed a bell-shaped jar full of air, which he had marked off into five equal parts. The phosphorus was then set on fire, and the stopper of the jar quickly put back in its place. Whilst the phosphorus was burning, the doctor explained that it was now uniting with all the oxygen of the air in the bell-jar to form the dense white fumes which were now visible. These, however, quickly dissolved in the water, leaving the jar perfectly clear once more.

"Look," said Harry; "some of the water has risen in the jar."

"Yes," said his uncle; "and it has filled up one of the parts into which I divided the jar. It has, in fact, taken the place of the oxygen. Most of the remaining four parts consist of the nitrogen, a fact which can be proved by removing the stopper and putting a lighted candle into it. See, the candle instantly goes out.

"The air we breathe, however, is not simply a mixture of nitrogen and oxygen; there is always a small quantity of a third gas present—carbonic acid gas, together with traces of ammonia and a variable amount of water-vapour; and recently the chemists have discovered it to contain a certain amount of gas they did not before know of, and to which they have given the name *Argon*. But very little is known about this gas yet, and we need not trouble ourselves about it. If we take 10,000 parts of what we commonly call 'fresh air', we shall find, neglecting the ammonia, argon, &c., they are made up of:—

Nitrogen,	7900	parts.
Oxygen,	2096	„
Carbonic Acid Gas,	4	„
	10,000	

"This will be sufficient for to-day; but by the time our next lesson arrives, I want you to be able to repeat this table from memory."

FOUL AIR.

By the apparatus upon the doctor's table the young people could see that some more experiments were in store for them in the next lesson. The first thing the doctor did was to light a small wax candle or taper, and place it under a tumbler turned upside down in a saucer. While he did this he asked his pupils to observe what took place.

Candle Extinguished.

In a short time the candle flame grew dimmer and dimmer, and then finally went out. "What has made the candle go out?" inquired the doctor.

"I expect the burning candle has used up all the oxygen of the air in the tumbler, and only left the nitrogen," answered Arthur.

"That is quite true; but it is only half the truth," said the doctor. "I will now pour some clear lime-water into the saucer and let some of it enter the tumbler. When I shake the lime-water in the tumbler, it instantly turns milky.

"This effect cannot be due to the oxygen or the

nitrogen, because you see if I shake up some lime-water first in this jar of nitrogen and then in that one of oxygen, it remains perfectly clear. So that the burning of the candle must have caused the formation of some new material which can turn lime-water milky. This new material is *carbonic acid gas*. From this experiment we learn that the composition of the air has been altered in two ways; the oxygen in it has disappeared or diminished in quantity, and carbonic acid gas has taken its place.

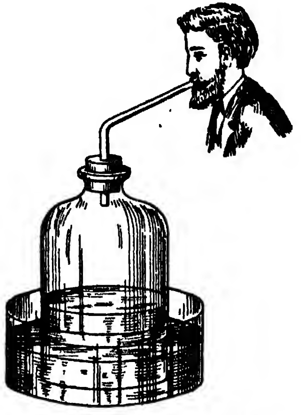
"Now suppose I could put a very large tumbler over Harry, just as I did over the candle. After leaving him in it for a time, we should find that the same changes would occur in the composition of the air in the tumbler. There would be less oxygen and more carbonic acid gas in it; and what is true in Harry's case is also true for other human beings and for every animal which breathes air. All rob the air of some of its oxygen, and add to it carbonic acid gas.

"A part of the next experiment Harry shall do for himself. Here is some clear lime-water, and I want you to breathe into it through this glass tube. You see the lime-water is now turning milky, and is becoming more and more milk-like as Harry continues to blow into it.

"Now into some fresh lime-water I will send a current of ordinary air by means of this small pair

of bellows; but you see it remains quite clear, for although there is a little carbonic acid gas in fresh air, there is not enough to produce any apparent change in the lime-water. These two experiments, therefore, clearly show that there is much more

Blowing air from the lungs through lime-water.



Method of showing the effect of Respiration upon the Air.

carbonic acid gas in the air we send out of our lungs than in that which we take in.

"One more experiment to show the difference between inspired and expired air, and then we shall have done for to-day."

Saying this the doctor took the bell-jar he had used in a previous lesson, and stood it in a deep basin partly filled with water. Removing the stopper, he inserted a lighted candle, and showed that it continued to burn. After withdrawing the candle, he placed in the neck of the jar a well-

fitting cork, through which passed a glass tube. Applying his mouth to the tube, he drew the air from the jar into his lungs—thereby making the water rise in the bell-jar—and then breathed again into the jar. Quickly removing the cork, the doctor lowered the lighted taper once more into the bell-jar. This time the light instantly went out, because of the large amount of carbonic acid gas present.

"The great lesson which is taught us here," concluded the doctor, "is that the air is so altered by breathing as to be unfit for breathing again."

THE DANGERS OF BREATHING IMPURE AIR.

"At the close of our talk yesterday," said the doctor next day, "I tried to impress upon you that air which has been once breathed is not fit to breathe again. Few people are aware of the power which foul air has over our health. This is because its action under ordinary circumstances is very slow. Yes, slow; but nevertheless sure.

"One of the most curious things about the human body is that to some extent it gets accustomed to bad air. This is why the change in the air from good to bad is not noticed by persons remaining in a crowded room; whereas if you go from the fresh air directly into the room you feel a difficulty

in breathing comfortably at first, and remark to yourself, 'How close it is!' By and by if you stay in the room for a time, you, too, get accustomed to the foul air, and the feeling of closeness which you experienced at first passes away. But because you are not made ill at once, you must not run away with the notion that the bad atmosphere is not injurious to you.

"Let me tell you about an experiment that was made with two sparrows. The first sparrow was placed in a glass bell-jar which contained sufficient air to enable it to live for three hours. Instead of being allowed to stay in the full time, it was taken out at the end of the second hour and set free. Without changing the air in the jar, sparrow No. 2 was put into the glass. This poor creature died at once; although the first sparrow might have remained there alive for another hour.

"Now, what do you think killed the second sparrow?" the doctor asked.

"I suppose it was the impure air from the first sparrow," said Ethel.

"Yes! But why should the first sparrow be able to live for another hour in the very air which killed the second one?" he asked again.

Each of the pupils had some idea about it, but could not put it into words. So the doctor explained that the first sparrow had become accustomed to its foul surroundings; but at the end of the

third hour its fate would have been the same as that of No. 2.

"To show you what can happen by breathing impure air," the doctor continued, "I will tell you the story of the Irish steamship *Londonderry*. On the night of December 1st, 1848, whilst crossing the Channel, the ship encountered a terrible gale. The waves washed over the deck of the ship to such an extent that the captain was afraid his ship would founder. So, for safety, all the passengers were ordered into the cabin under the deck; a room which was far too small to hold them comfortably. As soon as they were all inside, the hatches or doors of the cabin were closed and covered with tarpaulin to keep the water out. In this condition they were left for the night. In the morning, when the hatches were opened, of the 150 persons in the cabin, no fewer than 72 were found to be dead, and many others quite unconscious."

"That is nearly as bad as the Black Hole of Calcutta," said Arthur.

"Almost," said his uncle; "do you remember that story?"

Arthur said he had read it at school; and so for the time he became the teacher. He told his listeners how in India, a wretch named Surajah Dowlah had shut up 146 British men and women for about ten hours in a small dungeon, which had only two little windows on one side. Not enough

fresh air could get into the room, and so the poor prisoners had to breathe their own breath over and over again. In the morning, when the door was opened, 123 were found to be dead; and of the 23 who came out alive several died afterwards from the effects of that terrible night."

"It must be borne in mind, however," said the doctor, "that these ill effects of breathing impure air, are not due solely to the carbonic acid gas; for it has been proved that even after this gas has been removed from expired air it will kill mice put into it. So that there must be some other poisonous material sent from the lungs in addition to carbonic acid gas. This second impurity is waste *organic matter*. It has a very fetid smell, and is much more dangerous to health than carbonic acid; but its precise nature is not accurately known to chemists."

MORE EFFECTS OF IMPURE AIR.

When the doctor met his pupils again next day, he briefly repeated the chief points of the previous lesson, and spoke of the two instances that were given of rapid poisoning by bad air as being extreme cases.

"Unfortunately," he continued, "there is a great deal of ill-health which people cannot be made to believe is due to living in a foul atmosphere. Persons

who are in the habit of breathing impure air are always very pale, have but little appetite, and are continually 'out of sorts', as they say. The rosy cheeks of the country lads and lasses owe their colour chiefly to the fact that their owners live so much in the open air. Put a country girl into one of the close, stuffy rooms in any of our large towns, and it will not be long before the vitiated atmosphere tells its own tale.

"Whenever I happen to be in a badly ventilated room for a while, I begin to feel quite drowsy, and yawn time after time; and if I remain too long I am very apt to get a bad headache. No wonder therefore that people complain of feeling faint and ill after they have been sitting for hours in crowded rooms, such as theatres, and concert-rooms; especially at night, when the air is being further vitiated by the burning of gas-jets or candles.

"But the 'tale of mischief' does not end here. By constantly breathing such foul air from day to day the whole system is weakened. The respiratory organs particularly are rendered sensitive and become easily affected with *bronchitis*, or, worse still, with the much-dreaded *consumption.* In this part of the world, I rarely meet with the latter disease; but the medical men in large towns are only too painfully familiar with its work of destruction. Thousands of victims are claimed every year in the United Kingdom by this disease alone.

"I remember reading, in my student days, about a hospital for mothers and their new-born infants which, many years ago, was very badly looked after. No attempt, worth speaking of, was made to keep the air pure, and the result was that, out of 7650 infants born there in four years, 3000 died. Proper ventilation was afterwards carried out, and during the next four years only 279 died out of about the same number. So that the lives of over 2000 children were spared by letting their little lungs have plenty of fresh air.

"The same story could be told about the soldiers in the times when barrack-rooms were badly ventilated.

"Dumb animals, such as horses, sheep, and cows, also suffer in a similar way when they do not get sufficient fresh air. Some years ago a large number of sheep were brought to this country from Holland. During the voyage they were shut up in such a manner that very little fresh air could reach them. Upon the arrival of the ship on our shores it was found that six hundred and forty-six of the sheep were dead.

"When the cattle-plague broke out in this country, in 1866, thousands of cows died from the disease. Hoping to shut out the plague from the sheds in which the cows were kept, the owners stuffed straw and matting in every hole they could find. Instead of shutting the disease out, they were keeping it in;

for those animals that were in well-cleaned and well-ventilated sheds escaped almost entirely, while those pent up in the close sheds suffered severely.

"I could tell you much more about the dangers of breathing impure air, as, for example, the bad air from drains; but I think I have told you enough to show you the importance of always having plenty of pure air."

WHY WE EAT.

There could be no doubt that their holiday in the country was doing the two boys a great amount of good. The healthy colour of their faces showed it; and so did their appetites. Meal-times never came round without finding them ready for something to eat; and, in fairness to them, it must be said they always did ample justice to the good things put before them.

So next day the doctor said in a jocular way, "I don't know what you folks want to eat for?"

"Because we are hungry, uncle," said Arthur. "Running about in the fields, as we do, climbing trees, or jumping ditches, gives us such an appetite."

"And we should get thinner and thinner if we had no food," put in Ethel. "We should in time be little else than skin and bone."

"You are both right," said the doctor. "The reason why we must have food, and grow thinner

if we do not have it, is because the different parts of the body are being constantly used up to sustain life; pretty much in the same way as coal is used up in supporting a fire. And just as a fire goes out if we neglect to put on fresh coal, so would the body die for the want of fresh nourishment if we did not take food.

"All day long, and all night too, whether we are awake or asleep, whether we remain still or walk about, change and motion are always going on in the body. The rise and fall of the chest show that the lungs are being alternately filled and emptied; we can feel that the heart is beating; the pulse in the wrist shows that the blood is coursing through the arteries. Moreover, a great deal of work is done by the body. When we walk about, run, or jump, our muscles have to do work, just as they do when we perform any kind of labour.

"Now wherever there is motion or any work done, there is a corresponding amount of wear or waste of the material of the body. Take any engine or piece of machinery you like, you will find that its several parts are always being worn away by rubbing against each other; and the faster they move the faster they wear away. If this were allowed to go on unnoticed, the engine must ultimately come to a stand-still, which is prevented by having it put into a thorough state of repair from time to time.

"It is the same with the human body. The more we exert ourselves and work our limbs, the faster do we wear and waste away; so that, like the engine, the body must be kept in proper repair. This is done by means of the food we eat.

"Then again, you young people have not always been so big as you are now. I remember when Harry was a month old, he weighed only about ten pounds; now I suppose he would weigh nearly seventy pounds, and by the time he reaches my age he will weigh as much as 154 pounds. So from babyhood to manhood we steadily increase in weight, or, in other words, we grow bigger and bigger; and all this is accomplished by the food we eat.

"In many respects food is to the body what fuel is to the steam-engine. In both, the food or fuel is consumed by a process of burning, and in both cases heat is set free. You may wonder how this can be, since you see no fire and no smoke rising from the human body. The reason is this: the burning in the body is of a very slow kind, and only heat is liberated; in the furnace of the engine the combustion is much more rapid, and so both heat and light are produced.

"In the engine a large proportion of the heat is changed into work, while the remainder serves to make all the parts of the engine warm. It is just the same with the human body. Part of the heat

set free by the burning of our food is converted into work, while the remainder goes to keep the body warm.

"Before we finish I should like Harry to tell us briefly the chief uses or *functions* of the food we take."

"First," said Harry, "the food keeps us warm; secondly, it gives us strength to work; thirdly, it builds up the body; and lastly it—"

"Repairs the waste of the body," said Arthur, seeing that his brother had forgotten the fourth function of food.

WHAT SHALL WE EAT?

The doctor considered the subject of food of such importance in connection with health that he decided to devote another Talk to it. This time, however, he was to speak about the several classes of food that were required to meet the wants of the body.

"Yesterday," he began, "you will remember I pointed out, only in a different way, that our bodies required to be repaired, and to be built up, to be kept warm, and to have energy given to them to enable us to work; and I also told you that these wants of the body were satisfied by the food we eat.

"But since, except milk, there is no single food which can supply the body with all it needs, you

can plainly see that, in order to maintain health and strength we must eat different kinds of food. First of all, we find that food is required to build up the tissues of the body. A moment's consideration will tell us that in order to do this, the food must contain the same materials of which tissue is composed. Of the seventy simple substances or *elements* known to chemists, about fourteen are to be found in the body. The chief of these are *carbon*, *oxygen*, *hydrogen*, and *nitrogen*, together with smaller quantities of *sulphur* and *phosphorus*. The food we take therefore must contain an abundant supply of these six elements."

"But how are we to know which foods contain these particular substances?" asked Ethel.

"That has been done for us by the labours of many patient chemists who have carefully analysed, time after time, the various foods we take; so that their chemical composition is well known to us. Foods like lean meat, eggs, milk, bread, peas, and many others are found to consist chiefly of carbon, oxygen, hydrogen, and nitrogen; and it is only these foods which contain nitrogen that act chiefly in forming new tissue, such as flesh. They are called the *flesh-formers* or *nitrogenous foods*.

"In the second place, I told you that some foods were able to produce heat, and that a portion of the heat derived from their burning in the body was converted into work. These might therefore

be called the *heat and strength givers.* Analysis shows that they contain no nitrogen, being composed of carbon, hydrogen, and oxygen only; and since they are rich in the first of these three elements, they are generally spoken of as the *carbonaceous foods.* They include the *starchy foods*, such as sago, rice, tapioca, arrowroot, and potatoes; the *sugars*, such as cane-sugar and grape-sugar; and the *fatty foods*, such as butter, lard, dripping, and suet. All these foods contain the same three elements, and differ only from each other in the proportions in which these elements are found in them. Of all the carbonaceous foods the fats yield us the greatest amount of heat.

"Now you will understand why the Esquimaux, and all dwellers in cold countries, eat great quantities of blubber (whale-fat), and regard train-oil and other fats as greater luxuries than sago puddings.

"Lastly," he concluded, "I must tell you that all foods have a certain amount of water in them. Mushrooms, cabbages, and turnips contain a great deal; rice, arrowroot, and peas, very little. Most foods, moreover, contain a class of substances which are known as *mineral salts.* In meat, milk, and eggs we find *phosphate of lime*; and in the water we drink a little *carbonate of lime.* These two salts of lime help to make bone. All fruit and fresh vegetables also contain what are called the *salts of potash.* These are very useful in purifying

the blood. When no fresh vegetables are eaten, there breaks out a disease called scurvy, which formerly killed a large number of our sailors when out on long sea-voyages. Now, however, each sailor has a daily allowance of lime-juice to supply the salts, otherwise wanting in the food, and so ward off this horrible disease. In addition to the mineral foods just mentioned, *common salt* is also essential to life. Not only does it give flavour to the food, but also assists its digestion.

"To complete the lesson we will repeat the names of the three classes into which our foods are divided. They are—*nitrogenous foods*, *carbonaceous foods*, and *mineral foods.*"

A MIXED DIET.

When the time arrived for another conversation, the doctor remarked that the subject of food and feeding was such a large one that it was difficult to know what to leave unsaid. There was one point, however, that he must touch upon before leaving this question, and that was what he would call "A Mixed Diet".

"I can partly understand why we must have a 'mixed diet'," said Arthur, "from what you have already told us about the different functions of food."

"And if Ethel and Harry do also, then the task

before me will be a very easy one," said his uncle. "If the functions of each class of food are once fairly understood, it becomes abundantly plain that we cannot live upon any one class alone. Suppose we compelled Harry to live upon carbonaceous foods only, and Arthur upon the mineral foods, the result would be that both would daily lose flesh—would gradually waste away and die. If Ethel attempted to live on nitrogenous food only, she would not get enough carbon to keep up the warmth of her body, and to give her power to do work.

"Such experiments have been tried, but the people who attempted them very soon found out that not only had they lost their appetite for the food to which they restricted themselves, but actually came to loathe it.

"I hope, therefore, that you clearly see that it is impossible to maintain the human body in proper health and strength, unless we eat every day a sufficient quantity of the three entirely different classes of food—*nitrogenous*, *carbonaceous*, and *mineral*.

"Indeed, Nature seems to teach us to take such mixtures. Thus we like fat bacon along with those kinds of meat, such as veal or poultry, which are themselves poor in fat. Then we naturally use sauces, containing butter or other fats, with certain kinds of fish. If we make a rice, sago, or tapioca pudding we add butter and milk to supply the

fatty and nitrogenous materials in which those foods are deficient.

"Even our teeth indicate that the natural food of man is a mixture of animal and vegetable substances.

"When I come to speak about the teeth, as I hope to do to-morrow, you will find that some of them have broad flat tops or crowns, suitable for crushing and bruising vegetable foods, while the sharp-pointed edges of others are evidently meant for tearing animal foods to pieces.

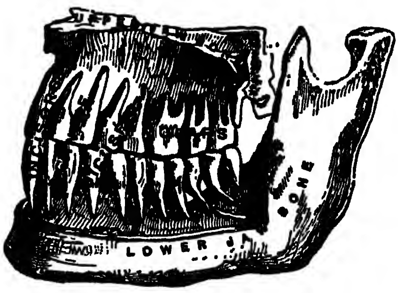
"Speaking of meat reminds me that some people maintain that we need not go to the animal kingdom at all for food, but that we can supply all our bodily wants from the vegetable world alone. This is perfectly true, but it is found that if we confine ourselves to a vegetable diet, we have to eat much more of it in order to obtain the amount of nourishment we could get from a much smaller quantity of animal food. Furthermore, animal food for most people is more digestible than vegetable food; and since our digestive organs are suited for both kinds, and since we have a taste for both kinds, it is more sensible to combine the two than to confine ourselves to the one kind only.

"It has been noticed that those races of men who partake of animal food are more active, brave, and spirited than those who subsist chiefly on vegetable food.

"At the same time an excess of flesh food is injurious, and those who habitually eat more meat than is good for them have to pay the penalty for their folly in the derangement of the digestive organs.'

THE DIGESTION OF FOOD.

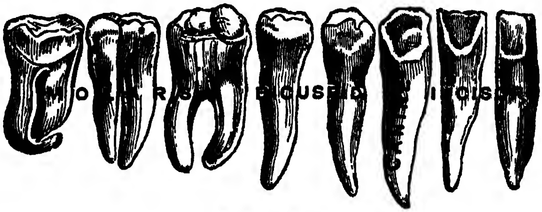
"Having answered the questions, Why we eat? and What shall we eat? to our satisfaction," began the doctor next day, "we must learn about the process by which food is *digested*; that is, how it is changed within the body and made into blood and then into bone, muscle, and fat.



Human Teeth.

"The first step in the process takes place in the mouth which receives the food. Here the solid portions of our food are cut up into small pieces or *masticated*, as it is called, by the teeth. In the course of our lifetime we have two sets of teeth. The first set, or *milk-teeth*, are twenty in number, and begin to appear in the child when it is between six and seven months old. After the age of six years the milk-teeth drop out, and are replaced by twenty-

eight of the second or *permanent* teeth. About the age of twenty-one years, four more permanent teeth make their appearance—commonly called "wisdom teeth", because they do not come through the gums until their owners are supposed to have learned wisdom. These complete the set, which, if none



The Teeth Classified.

have been lost, number thirty-two teeth in all,—sixteen in the upper jaw and sixteen in the lower jaw.

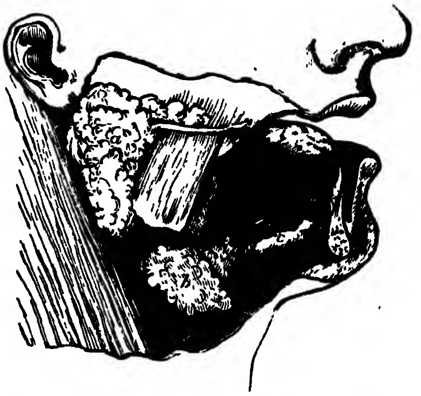
"From the next picture you can see for yourselves that the teeth are of different patterns. Those in the front of the mouth—four in the top and four in the bottom jaw—are shaped like chisels, and are the *incisors* or cutting teeth. They are used when we bite a piece of bread, for example.

"Next to these come the four pointed, or dog-teeth, called *canine teeth*, one on each side of each jaw; they are used for tearing meat.

"Next to the *canine* teeth, are eight *bicuspids*, or teeth with two points. They are useful for both tearing and grinding food. Of these there are two on each side of the jaw.

"Lastly come the true grinders or *molars*. These are the strongest teeth in the head, and are twelve in number, three on each side of the jaw. They grind the food to a pulp.

"Now, you must have noticed that, whilst you are chewing your food, it gradually becomes wetter. This is because there is poured upon it a fluid called *saliva*. When you have been standing in front of the pastry-cook's shop, I am sure you have felt your mouths watering at the good things displayed in the window. This water or saliva comes from six little bags, or glands, which open into the mouth.



Salivary Glands. *a*, Parotid; *b*, submaxillary; *c*, sublingual.

"When we are not eating, only sufficient saliva runs into the mouth to keep it comfortably moist; but as soon as we begin to eat, the salivary glands pour a larger quantity upon the food, sometimes as much as half-a-pint in a single meal.

"This saliva not only moistens the food and makes it easier to swallow, but also changes a

portion of the starch in our food into sugar. You may prove this for yourselves. If you slowly eat a piece of bread (which contains starch) you will find that it becomes slightly sweeter to the taste.

"Now, this is a most important use of the saliva; for starch is insoluble in water, and would therefore be of no use to us as food. Sugar, on the other hand, readily dissolves, and is therefore easily digested.

"This is one of the reasons why we should take plenty of time to chew our food. You remember the old saying, 'Many hands make light work'; and if one person neglects his work, another has to do it. If we prevent the saliva doing its work, we give other members of the body more to do, and in time they get tired and out of order. Remember, therefore, to eat slowly and chew your food thoroughly."

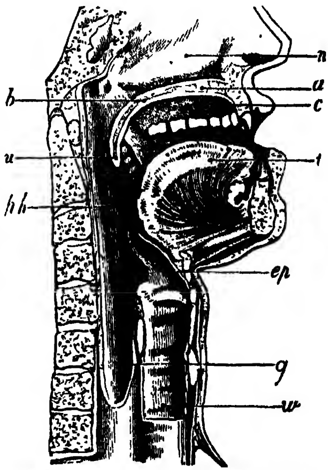
SWALLOWING.

Next day the story of the journey of the food in the body was continued. Having briefly summed up the chief points of the previous lesson, the doctor went on to explain that after the food has been first cut up into pieces by the teeth, and been made soft by the saliva, the tongue rolls it into a ball and sends it to the back of the mouth.

"If you take a looking-glass," continued the

doctor, "and open your mouth as wide as possible, you will see at the back of the mouth a little piece of flesh hanging from the upper jaw. It is known as the *uvula.* Directly the uvula is touched by our food, it springs up and closes the opening leading to the nose, so that the food may not pass that way when we swallow.

"The passage to the nose being closed, there are still two other tubes which open from the back of the mouth. One is the *gullet*, and the other, immediately in front of it, is the *windpipe.* If by accident a little food or water goes *the wrong way*, or down the windpipe, it takes the road to the lungs instead of the one which leads to the stomach. A fit of coughing immediately ensues, and does not cease until the offending particle has been expelled. Should the food become so fixed that it cannot be removed, we should quickly choke to death.



Section showing Mouth and Nasal Cavities, Gullet, Windpipe, &c.

t, tongue; *ph*, pharynx; *ep*, epiglottis; *g*, gullet; *w*, windpipe; *n*, one of the turbinated bones of the nose; *a*, hard palate; *b*, soft palate; *c*, roof of mouth; *u*, uvula.

"To guard against such a calamity, there is at

the top of the windpipe a sort of trap-door called the *epiglottis*; and, every time we swallow, it drops down and covers the windpipe, so that the food passes harmlessly over it into the gullet. Be sure, therefore, never to attempt to speak when you are in the act of swallowing; because speaking opens the windpipe just as in breathing.

"Supposing no accident to have happened, the food is now in the 'Red Lane' or gullet, on its way to the stomach. In its descent it does not drop down by its own weight, but is gradually pushed onwards by a peculiar motion of the gullet. Wherever the food happens to be in the gullet, the muscular fibres immediately behind it press it on, step by step, till it reaches the stomach.

"You have seen a horse drinking at a trough by the wayside. Every time he gulped up the water, if you watched closely you would see a swelling moving upwards along its throat; the water flowing uphill, as it were.

"If it were not for the muscles in their throats, the horse and other four-footed animals would not be able to eat and drink with their heads down. If the food simply dropped down the gullet, they would be compelled to lift their heads high up to get rid of each mouthful.

"So you must not think that it is any particular position of your body—whether standing or sitting—that sends the food down to your stomach; it

would reach the stomach just the same if you stood on your head. A frequent performance of a juggler is to drink a glass of water whilst standing on his

head; but you see there is nothing very wonderful in the feat after all."

"Do you think I could do it," asked Harry, always ready to try a new experiment.

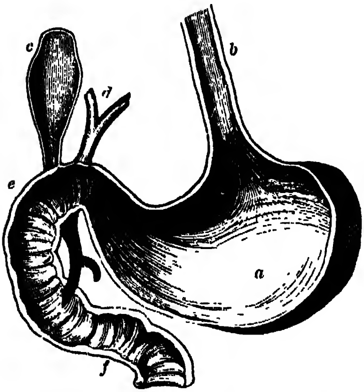
"I daresay you could if you were to try, but I recommend you not to attempt it. We are made to stand on our feet, and not our heads.

"But to return to the food. When it has traversed the length of the gullet, a distance of about nine inches, it enters the second organ of

digestion—the stomach, where we had better leave it for to-day. Not that it will stay there for our pleasure. No; by the time our next lesson arrives, it will have left that organ some hours."

MORE ABOUT DIGESTION.

"In our last lesson," the doctor began next day, "we traced the journey of the food as far as the stomach. As we cannot see inside our bodies, I have obtained some pictures to show you what the organs, I have to talk about to-day, are like.

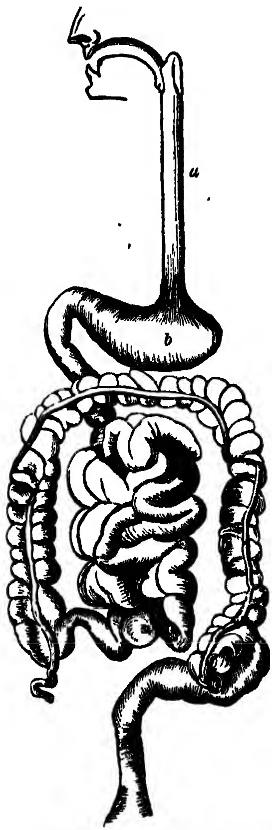


a, Stomach; *b*, Gullet; *c*, Gall-bladder; *d*, Bile-duct; *e*, Pylorus; *f*, Duodenum.

"The stomach, marked *a* in the picture, looks something like the bagpipe upon which you may sometimes see strolling players perform in our streets. It has two openings—one through which the food enters from the gullet, *b*, the other for the digested food to pass out, *e*, *f*.

"When the food enters the stomach it is not allowed any time to rest, but is kept moving round and round, just as the cream is kept moving about

in the churn to be made into butter. At the same time, thousands of tiny bags or glands, which lie in the walls of the stomach, pour upon the food an acid fluid called *gastric juice.* This juice dissolves lean meat and other foods of the same class, and by the time it has done its work, the food is changed into a substance called *chyme*, which looks very much like pea-soup. The gastric juice has no action on fat, except to break up the skin in which it may be held. The starchy foods, also, whose digestion was commenced by the saliva, are stopped in the process by the gastric juice, and their digestion is only resumed in the intestines.



Alimentary Canal, including Gullet (*a*), Stomach (*b*), Large and Small Intestines.

"Much of the digested food in the stomach makes its way at once into the blood by soaking through the walls of the delicate and numerous blood-vessels in the sides of the stomach. The remaining portion passes on from the stomach into the *small intestines* after an

interval of not less than two hours from the time the food first entered the stomach.

"To give you some idea of the action of gastric juice, I minced a small piece of meat this morning, and put it in a little water with some juice I obtained from the inside lining of a calf's stomach. Whilst I was out in the village, your aunt kept the mixture warm in a pipkin, at a temperature of about 100°."

When the doctor brought in the pipkin from the kitchen, the pupils saw that there was now a kind of pulp or thick soup in it. Taking a little of the pulp out of the pipkin, the doctor squeezed it between his fingers.

"How soft it is!" remarked Ethel.

"Yes, perfectly soft," said her father; "and that is what happens to all the flesh-like substances you eat when they reach the stomach.

"So far, then," resumed the doctor, "we have seen that the saliva changes the starchy food into sugar, and the gastric juice dissolves the nitrogenous substances. But in an ordinary meal there are other materials besides the starchy and nitrogenous, such as fats, vegetable fibres, and many others.

"These are not acted upon until they reach the small intestines which I have already mentioned. Here two more fluids are poured upon the food. One of these is *bile*, which is formed by an organ

called the *liver*; the other is the *pancreatic juice*, made by another organ called the *pancreas* or *sweetbread*.

"The bile flows down the little pipe marked *d* in my first picture, and contains a great deal of soda. To explain the use of the bile I will show you an experiment or two."

The first experiment the doctor did was to pour some water into a glass flask he kept for the purpose, and afterwards to add some olive-oil. After giving the bottle a good shaking, the young folks saw that the water and oil would not mix; the oil kept quite separate, simply floating on the top of the water.

To some olive-oil in another flask he added a solution of soda. In a short time the two had mixed together, and formed a thick creamy-looking liquid.

"This simple experiment," continued the doctor, "will show you the use of the bile. By its action all the fat we eat is broken up into a fluid like cream.

"The pancreatic juice completes the work begun in the mouth. Any starch which escaped the action of the saliva is converted in the small intestine to sugar by the pancreatic juice. Moreover, the pancreatic juice digests nitrogenous foods as gastric juice does, and breaks up fat as the bile does. In fact, the pancreatic juice is the most perfect digestive fluid of the four I have named.

"Lastly, by the motion of the small intestines, the food is squeezed onwards to the large intestine; and as it moves along, all the digested matters are absorbed by the walls of the intestines, and passed into the blood.

"And now I have completed my task of showing you how the food we eat is made into blood."

INDIGESTION.

On the following day the doctor had scarcely taken his usual place, when Arthur commenced the day's talk by asking his uncle to tell them something about "Indigestion".

"I have often heard father speak of it," he said; "but I never knew what it meant."

"I should be very sorry for you if you did!" said his uncle. "Young people as a rule don't suffer from indigestion, luckily for them. Only those who have lost it can appreciate the priceless treasure of a good digestion.

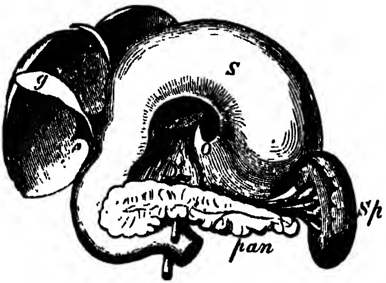
"In health, the changes by which food is made into blood take place without our being conscious of them. If the food is wholesome, and we eat no more than is good for us, it is easily digested and does service to the body. And yet what do we find? The majority of us, I can safely say, play all sorts of tricks with our stomachs.

"In the first place, we thrust upon the stomach food which either gives it a great deal of trouble to digest, or which it cannot possibly digest at all. Of course, the stomach cannot long bear this ill-treatment, and it breaks down; then there is an end to health and comfort. Food which is either cooked *too much* or *too little*, and unwholesome food, such as stale meat and fish, or unripe fruit, are common causes of indigestion.

"Overloading the stomach, either by eating too much at a time, or by taking food too frequently, is another bad practice. Food, like medicine, ought to be taken in proper quantities at regular times. During the course of a day, about fifteen pints of gastric juice are poured into the stomach; and it is easy to see that if we eat more than this quantity of juice can dissolve, a portion of the food must remain undigested. This will very likely give rise to "windiness" or *flatulency*, which is only a form of indigestion. Instead of the food being made into blood, it seems to turn to wind, and puffs up the stomach so much that a most uneasy feeling is the result.

"Or indigestion may take the form of *acidity*, or sourness of the stomach, a very disagreeable form indeed. In this case the trouble is due to an excess of acid juices in the stomach. By attempting to get rid of these, the stomach forces a portion up the gullet and into the mouth. This leaves a

hot, burning sensation in the throat, and folks say that they have the 'heart-burn'. 'Stomach-burn', I should say, would be a more suitable name for it; for this complaint has but little to do with the heart.



Relative positions of the Stomach (*S*), Liver (*L*), and Gall-bladder (*g*), the Pancreas (*pan*), and Spleen (*Sp*). The stomach is here represented so as to show its *under* surface and the under surface of the liver.

"Indigestion may also arise from the improper working of some other organ. The liver in particular is very liable to get out of order and cause digestive disturbances. Through overwork or some other cause, it may fail to send sufficient bile to the small intestine. Digestion in that organ is at once interfered with, and the complaint soon spreads to the stomach. This accounts for the odd saying, 'Happy is the man who does not know he has a liver'.

"I have already warned you to eat slowly and chew the food thoroughly. Food is too frequently eaten in a great hurry. The teeth have not time enough to grind it properly, and so we swallow hard lumps of half-chewed meat. If we try to grind pebbles in a coffee-mill, probably we shall not succeed, but we shall certainly damage our mill. Yet this is the sort of prank that many people commonly play with their stomachs.

"Now the examples I have given are only a tithe of the causes of indigestion. I shall only have time to name a few others, but what I have said may be sufficient to help you to take care of yourselves, since you are babies no longer.

"Mentioning 'babies' reminds me that many a little infant has died through the ignorant mother giving it improper or starchy foods before it has any saliva to digest them with. Most of the *convulsions* of childhood can be traced to the use of improper food.

"Indigestion is sometimes caused by intense studying immediately after meals. Also the habit of 'washing down the food' with water or other liquids is often the cause of indigestion. Never eat and drink at the same time. The food, if properly chewed, is sufficiently moistened by the saliva to be easily swallowed, and does not need 'washing down'. The practice of sipping some beverage after each mouthful of food dilutes the saliva to such an extent that the starchy foods are scarcely acted upon in the mouth.

"It is bad enough to 'wash down' the food with water, but it is infinitely worse to do so with alcohol or tea. Water at least assists in dissolving the food when it reaches the stomach; the other beverages do not, and strong alcoholic drinks are apt to stop digestion altogether.

THE STOMACH AND THE MEMBERS.

Once on a time, the fable says,
The members of the body rose
As rebels 'gainst the stomach's ways,
And thus proclaimed their woes:

"We sweat like beasts of burden all,
While 'Stomach' all the profit takes;
Arms, legs, and every other part,
To find him food, he servants makes.

"Let us throw off his hated yoke,
And take the profit of our toil;
'Tis we that do the work like slaves,
Whilst he above reaps all the spoil."

No sooner said than done! As soon
The error of their ways they found!
The heart grew faint, their strength as weak
As water spilled upon the ground.

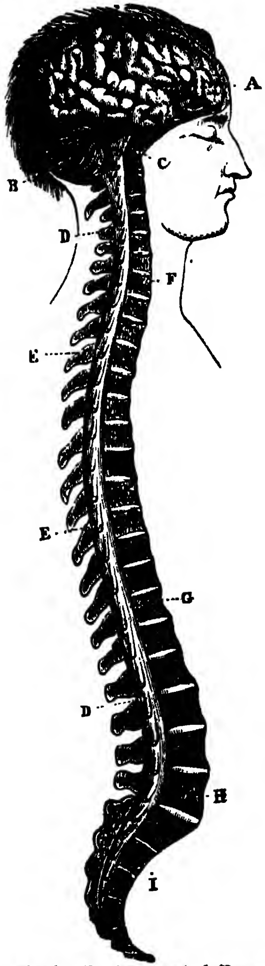
The stomach shared with all the rest
The common stock of food, they learned;
Each worked for all, and all for each,
And each partook of what he earned.

HOW MESSAGES ARE SENT THROUGH THE BODY.

Interesting as the several portions of the body described by the doctor had been, perhaps, the most wonderful part of all the human machinery was that reserved for the next lesson. As a

suitable way of introducing the subject, the doctor commenced by speaking of the mills and workshops in our large towns. He pointed out how necessary it was in any business undertaking to have a manager or director to see that everything went on smoothly, and to whom complaints or questions relating to the business could be addressed.

"So, too," continued the doctor, "there is a manager or director in the human workshop, known as the brain; and no movement which we willingly make is done without the permission of that member. In health, in fact, nothing is done either in or by the body that escapes the ever-watchful eye of the brain. If a pin has entered your flesh, or some one has pinched you, or stepped on your toes, the brain is quickly told all about it by those



Showing the Cerebro-spinal Nervous Centre. Along the whole length of the Spinal Cord may be seen the roots of the spinal nerves.

A B C, Brain; D E E D, spinal cord; F G H I, backbone.

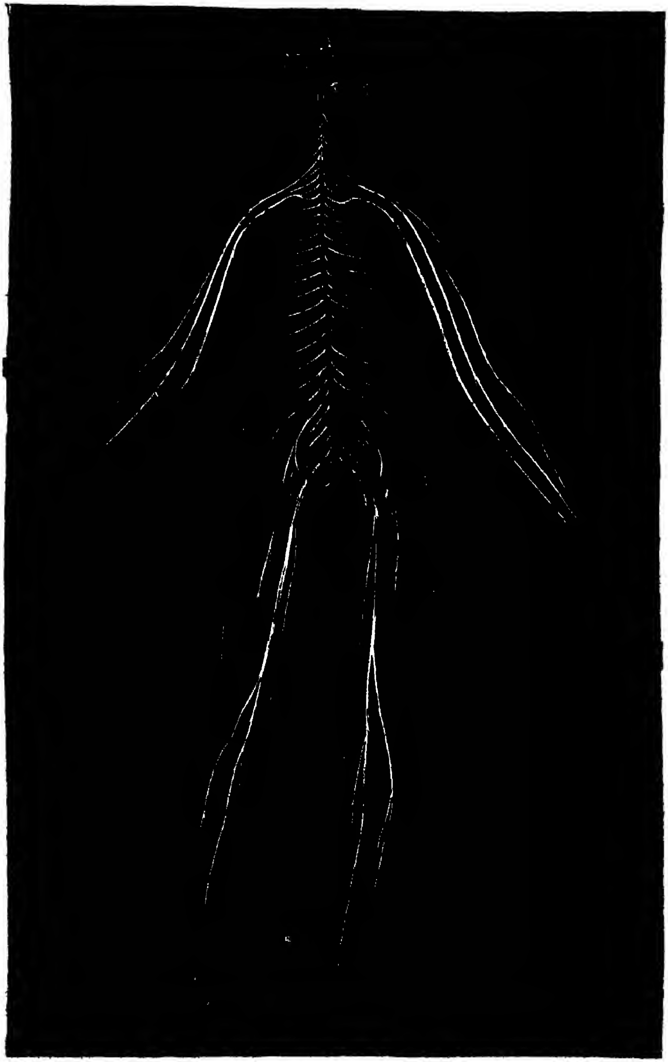
thousands of tiny white threads, the *nerves*, which lead from every part of the body to the brain."

"That sounds very much like sending a message by telephone or by telegraph," said Arthur.

"It does," said his uncle; "the nervous system can be very aptly compared to a complete telegraphic system. The brain itself is the head office, and the numerous nerves branching from it to all parts of the body are the telegraph wires which carry the messages. By means of these nerves messages, or *impulses* as they are called, are constantly being sent to the brain to acquaint it with what is going on in the different parts of the body. Upon the receipt of the intelligence, the brain immediately sends back instructions as to what must be done in each case.

"For instance, if I put my hand on anything hot, the nerves in that part of the hand that is burnt, carry the sense of the injury to the brain, and this makes me aware of the danger. Instantly the brain sends back a message, *along another set of nerves*, to take the hand off the hot article.

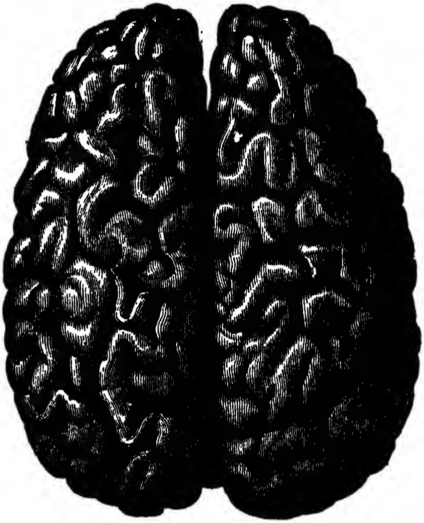
"Our nervous system may be said to consist of three parts,—the Brain, the Spinal Cord, and the Nerves. The brain completely fills the cavity of the skull, and is usually from 52 to 56 ounces in weight in man, and from 44 to 47 ounces in woman. Looked at from the outside the brain is seen to be covered with a pinkish-grey substance about one-



Nervous System.

eighth of an inch in thickness; but, when laid open, the interior is found to consist of white nerve matter.

"Here is a picture of the top of our brain; and you see it is divided from front to back into two equal parts or hemispheres. These two hemispheres, however, are not entirely separated from each other. They are connected in the centre of the brain by what we may call a bridge, and together form what is known as the big brain or *cerebrum.* This portion of the brain begins on a level with the eyebrows, and extends to within two inches of the point where the hair ends at the back of the head.



Upper Surface of the Brain.

"Another curious feature about the cerebrum is that its surface has a peculiar convoluted or folded-up appearance. If I crumple up my handkerchief into folds you will easily see why the surface of

the brain appears as it does. From numerous examinations of the brains of different animals it appears that a high degree of intelligence is always associated with a great folding of the brain substance. As we descend in the animal scale it is found that the brain becomes less and less convoluted, until, as in the rodents or gnawing animals, it is quite smooth. If you pinch or press the cerebrum, you cause no pain, because it is not what we call the seat of sensation or feeling. But nevertheless a blow would do it great injury; because all power of thought and memory would be taken away.

"Underneath the cerebrum, at the back, is the lesser brain or *cerebellum*. You can see it plainly in my first picture. It is much smaller than the big brain, and injury to it makes us lose all control over our muscles.

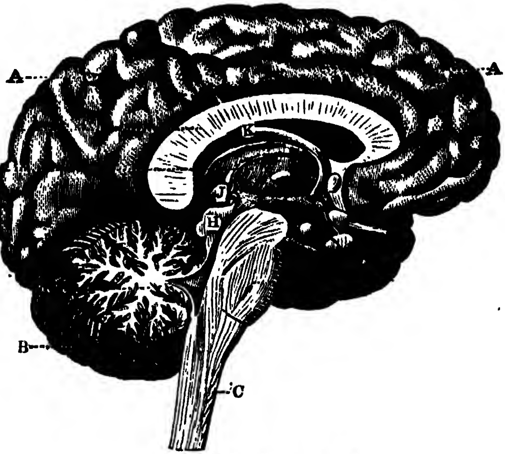
"In babies the bones of the skull are separate, and only grow together as the baby gets older. The spaces between the bones give the little brain room to grow. An infant's brain may therefore be easily injured by a knock or any pressure upon the skull."

MORE ABOUT THE NERVOUS SYSTEM.

"In our talk yesterday about the nervous system," began the doctor next day, "we only managed

to get as far as the brain; and you will remember that I said there were two brains, the big brain and the lesser brain.

"Here is a picture of a section of the brain through the deep cleft or fissure which I said divided



Section of the Brain along the great fissure.

A, Cerebrum; B, cerebellum; C, medulla oblongata.

the big brain into two hemispheres. You will see the two parts much better in this picture than in the one I showed you yesterday. It also shows you another portion of the brain which is the most important of all; because the least injury to it causes instant death. It is the *Oblong Marrow*, or, since I know Harry likes long names, the *medulla oblongata.* It is about an inch and a half long, and half an inch thick; and you will see from the

picture that it is broader just where it joins the brain than it is lower down where it is connected with another part of the nervous system, the spinal cord. It is, as a matter of fact, the enlarged end of the spinal cord as it enters the brain.

"The spinal cord is from sixteen to eighteen inches long in grown-up people. From either side of it spring those nerves which spread out all over the body like a fine white network. Each spinal nerve consists really of two nerves wrapped up side by side in a sort of sheath or covering. One of these is the nerve of feeling (*sensory nerve*), and the other is the nerve of motion (*motor nerve*). Besides these sensory and motor nerves there are others known as the *sympathetic nerves*, which are distributed chiefly to the walls of the blood-vessels and which control, to a great extent, the flow of blood through them.

"You will remember that I told you yesterday that the nerves carried messages to the brain; but I did not tell you by which road the messages travelled. Now I can do so. When Ethel pricks her finger with a needle, a message travels up the *nerve of feeling* in her arm to the spinal cord. Before reaching the spinal cord, however, it has to get between the bones of the vertebral column; but once in the cord, the message rushes upwards through the medulla and so into the brain. Immediately, the brain interprets what is wrong,

and a reply to the message is sent through the medulla and spinal cord, and along the *nerve of motion*, telling her to pull her hand smartly back, and perhaps to put the injured finger into her mouth.

"But suppose Ethel had unfortunately met with an accident which had severed the *nerve of feeling* in her arm; what do you think would then have happened if she had run the needle into her finger?"

"Nothing, I should say," said Arthur; "at least she would feel no pain, because the message from her finger could not reach the brain."

"It is quite a common thing in the winter time for men who have suffered amputation of the legs to complain of cold feet. Now, having no feet, they cannot possibly feel cold in them. It is cold in the stumps affecting those nerves that had been accustomed to convey the news of cold feet to the brain. This the brain as usual reads as *cold feet*."

HOW TO KEEP THE BRAIN HEALTHY.

When the pupils met again for another lecture, the doctor said, "I cannot leave the subject of the nervous system without saying a little about the risks we run through not keeping it in a healthy condition.

"In one sense, the nervous system is like the mainspring of a watch. Both are easily put out of order, and the effect in each case is a breakdown in the mechanism they control. In order, therefore, to keep the brain, which is the centre of the nervous system, in a healthy state, it must receive the same treatment as the other parts of the body; that is, it must have a proper supply of pure blood, exercise, and rest."

"I know what is meant by exercising the muscles," said Arthur; "but I am not sure whether I understand what you mean by exercising the brain."

"Let me explain. Of course you cannot exercise your brain in the same way as you do your muscles; but you can give it some regular work to do, as you are doing now, by trying to learn all I tell you. Your arms and legs would never grow strong if you never used them, neither will your brain grow strong if you fail to exercise it.

"Never follow in the footsteps of the little country boy, who, when he was asked 'What he was thinking about,' replied, 'Mostly nought, master'.

"An old proverb tells us that 'Nought comes from nought', and people who go through life thinking mostly about nothing, never come to much good.

"The development of the brain in man progresses more slowly than in animals, and is therefore longer in attaining its full power; but it is subject to the

same laws of waste and repair as other parts of the body. The effect of study, providing there are proper periods of repose, is to increase the weight of the brain; and the brains of some clever men have

Cuvier.

been known to weigh over 60 ounces. The brain of Cuvier, the naturalist, weighed 64½ ounces, and that of Dr. Abercrombie, the celebrated physician, 63 ounces.

"Of course there are exceptions to the rule that large brains are the best; but usually it is found that all those who are regularly engaged in active duties have a brain of good size. A condition necessary to a healthy brain is a proper supply of blood of good quality. Now, without sufficient food it is impossible to get good blood, and this explains why hungry boys and girls cannot give close attention to mental work. Moreover, the effects of starvation in producing brain disorders, such as delirium during periods of famine, is well known. Under ordinary circumstances, feebleness of brain power is the outcome of ignorance and indolence, together with the lack of nourishing food.

"A not infrequent cause of idiotcy in children is *fright.* I do hope that neither of you boys will

ever do anything to frighten a little child; I know of nothing more dangerous. Children are naturally very timid and full of fears, and what would not have the least effect upon a youth or man, might throw a child into fits.

"Once a doctor was sent for to see a little fellow who was suffering from croup. Now it seems that those in charge of him had been in the habit of threatening him that, if he were naughty, the doctor would come and cut him up. When the doctor arrived the poor boy was so terrified that he died of shock. Of course he fully believed that the doctor had come to cut him up, and thus a life was lost really through the stupidity of the parents.

"Even supposing the child is not terrified sufficiently to cause injury to the brain, it may by carelessness be made exceedingly timid and nervous through life."

HEALTHY EXERCISE.

Breakfast was scarcely over next morning before the vicar's youngest daughter called to invite Ethel and the two boys to tea at the Rectory that afternoon. Satisfied with the progress that had been made with the lessons, and as the day was beautifully fine, the doctor said he would accompany them for the sake of the walk.

"In my opinion," said he, as they set out for

the Rectory after dinner, "a good walk is one of the best forms of exercise that a person can take. The poet Dryden thought so, too, when he penned the lines:—

"'Better to hunt in fields for health unbought,
Than fee the doctor for a nauseous draught;
The wise for cure on exercise depend:
God never made his work for man to mend.'

"But unless the walk is taken with a certain object, it soon becomes wearisome and monotonous. When there is some object of interest in view, it is at once healthy and delightful. I am sure Ethel must derive a great amount of pleasure in her walks by collecting the wild flowers in the hedgerows and fields."

"Most certainly I do," replied that little woman. "Besides, I learn a great deal from doing so."

"Then you agree with Wordsworth, when he says—

"'Come forth into the light of things—
Let Nature be your teacher.'"

The words had scarcely left the doctor's lips before a lesson from Nature presented itself. In front of one of the cottages several kittens were playing and gambolling about their mother in a most frolicsome manner.

"There is a lesson for you young folks," said the doctor, as he paused to watch the kittens' move-

ments. "The playfulness shown by all young animals is only one of Nature's plans for making them grow. The exercise which they get in this way makes every part of their bodies steadily

increase in size and strength; and what is true in their case is also true in ours. Take our village blacksmith, for example. Like the one that Longfellow, the poet, wrote about:—

"'The smith a mighty man is he,
With large and sinewy hands;
And the muscles of his brawny arms
Are strong as iron bands'."

"I have often watched him swinging those great hammers about," said Arthur; "it is as much as I can do to lift one of them."

"Yes; but if you began by first using a small hammer, as he did when a boy, you would find that you would grow stronger daily, and in time be able to use the large ones as easily as he does. By exercise, the muscles grow larger, firmer, and at the same time more powerful.

"On the other hand, deficient exercise will cause the muscles to become flabby and waste away. This is clearly shown in the case of a limb confined for many weeks in splints. As soon as the broken bones have grown together again and the splints are removed, it is seen that the limb has become thin and almost powerless.

"So you boys may indulge in any manly sport or game, knowing that you are always strengthening your muscles by your play. But let your exercise be such as will bring *all* your muscles into play, and not one set only. Perhaps the only warning I need give you is to avoid over-exerting yourselves. This is most likely to happen in field sports. A youth, anxious to win his 'heat' in a foot-race, for instance, is so encouraged by the cheers of his comrades, that he is apt to suddenly over-exert himself, and thus tax the strength of his heart and blood-vessels."

As they approached the Rectory, they met the

wife of one of the farmers carrying a large basket of eggs and butter to the station.

"You have a big load, Mrs. Lane," said the doctor smiling.

"Yes; but I am used to it," said Mrs. Lane.

"I expect you will be ready for something to eat by the time you come back," said the doctor.

"That I shall. Work is a grand thing to give you an appetite. If you only saw how my lads eat you would be astonished."

"No doubt; and I daresay they sleep well at night, too," said the doctor.

"Sleep! Yes, like tops; and so do I," said Mrs. Lane, as she walked on.

"A good appetite and ability to sleep well are two other benefits to be obtained from plenty of exercise," continued the doctor; "but as we have reached our destination, we must close the conversation on the value of exercise now."

So after a short rest, and a chat with the vicar and his good lady, the doctor returned home, feeling all the better for the pleasant walk with his young "charges".

THE NEED OF REST.

When the young folks reached home from the Rectory that evening all three were tired out and quite ready for bed. In fact, Harry could barely

keep his eyes open, while the other two were chatting about the games they had played that afternoon.

Just to hear what they would say the doctor suggested that they should chop some firewood for the morning before saying good-night.

"Oh, uncle," said Arthur, "I am really too tired to-night! I will get up early in the morning to do it."

"Very well," said his uncle laughing. "I suppose I must let you off this time; the body is not meant to be always at work. We must give it proper rest or else it will become worn out and good for nothing."

So saying, he wished them a very good night, and it was not long ere they were sound asleep.

When the time arrived for the talk next day, the doctor continued to tell them about the importance of sufficient rest and how necessary it was for good health.

"We are all perfectly familiar with sleep," he said, "and yet how many of us can say what it is, and what it does for us. Shakespeare calls it 'the chief nourisher of life's feast', and such a description at once shows us that he was fully aware of its value to the human body. Without sleep life could not last long. We may, by an effort of will, put off sleep for a time, but we cannot do without it altogether. Worn out by our daily labours, we lie down, and awake refreshed in the morning; both

brain and muscles have been fitted for another day's work, and so 'man goeth forth to his work again until the evening'.

"Young people especially require plenty of sleep, because they grow so rapidly, and it is only during the periods of rest that growth goes on. It is sad in large towns to see the number of children that are in the streets late at night. Deprived of sleep and exposed to all weathers, no wonder they grow up weak and stunted men and women, instead of the robust citizens we so much desire.

"The best sleep is sound sleep, and the first sleep at night is generally deeper and better than that towards the waking hours. This explains the old saying that 'An hour's sleep before midnight is worth two after it'. Restless, fitful sleep, interrupted by starting, or crowded with dreams, is not refreshing, and a person awakes in the morning with a feeling of weakness. Wordsworth knew the value of sound sleep, for he says:—

"'Even thus last night, and two nights more I lay,
And could not win thee, Sleep! by any stealth;
So do not let me wear to-night away,
Without Thee what is all the morning's wealth?
Come, blessed barrier between day and day,
Dear mother of fresh thoughts and joyous health!'

"Sleeplessness is one of the most distressing complaints which can afflict mankind. It may arise

from many causes; overwork, especially too much brain work late at night, being one of the chief. Retiring to rest immediately after partaking a hearty supper is another cause; although going to bed hungry does not contribute to sound sleeping. He who desires to sleep well should feed lightly. The remedy for sleeplessness, of course, is to avoid the causes which produce it. A warm bath before getting into bed is an excellent means of inducing sleep. Putting the feet into hot water, to which a little mustard has been added, is also to be recommended.

"Several explanations have been offered to account for the body passing into the mysterious state called sleep. Surgeons who have had the rare opportunity of seeing the brain in this condition, say that sleep is due to a diminution of the amount of blood in that organ. As drowsiness comes on, the brain, which is of a reddish colour when the mind is at work, is seen to gradually become paler and paler, because of its increasing bloodlessness; and at last, when sleep arrives, the brain is at its palest. Upon awakening, the reverse action to this takes place. The brain then gradually grows redder until all the faculties are fully aroused, when it is once more at its ruddiest hue.

"But sleep is not the only form of rest possible. It has been rightly said that 'the best rest is a change of work', and the truth of this any one

can prove for himself. I know in my own case when I have been studying hard nothing seems to do me more good than to go into the garden and dig. On the other hand, if I were a labourer or a blacksmith, working with my arms and legs all day long, the best way for me to take rest would be to sit down and read, or to take up some branch of study when my daily task was over. Cowper the poet puts it clearly when he says:

"'Absence of occupation is not rest,
A mind quite vacant is a mind distrest'.

"One thing, however, must be guarded against, and that is, not to continue brain work up to the time of retiring to rest. There should always be an end to lessons for at least an hour before bed-time, and simply quiet, cheerful occupation indulged in. Children especially should have what Longfellow calls the "Children's Hour"—to romp about, to shout, to sing, and, in a word, to play—

"'Between the dark and the daylight,
When the night is beginning to lower,
Comes a pause in the day's occupation,
Which is known as the Children's Hour'."

THE QUIET LIFE.

Happy the man, whose wish and care
A few paternal acres bound,
Content to breathe his native air
In his own ground.

Whose herds with milk, whose fields with bread,
Whose flocks supply him with attire,
Whose trees in summer yield him shade,
In winter, fire.

Blest, who can unconcern'dly find
Hours, days, and years, slide soft away
In health of body, peace of mind,
Quiet by day.

Sound sleep by night, study and ease
Together mix'd, sweet recreation,
And innocence, which most does please
With meditation.

Thus let me live, unseen, unknown,
Thus unlamented let me die,
Steal from the world, and not a stone
Tell where I lie.

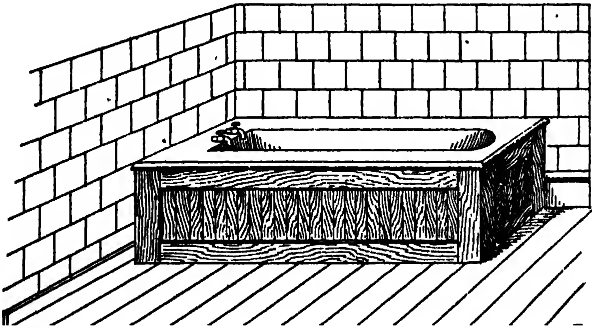
—*A. Pope.*

HOW TO KEEP THE SKIN CLEAN.

At the outset of the next lesson the doctor related some of his experiences since he began visiting the homes of his patients; and, as he said, he was sorry to admit that a very large amount of the ill-health which exists is entirely due to dirt. When people

are dirty in their persons, and dirty in their homes, it is really no wonder that sickness prevails. To see the skins of some persons in our large towns, one would think that water was a shilling a pint, and that soap was never heard of.

"I have told you in a former chat what are the



The Bath-room.

effects of impure air, and on another occasion I dwelt upon the danger of neglecting to keep our skin clean; so that to-day I need only speak about the best ways of keeping the whole body perfectly sweet and clean.

"To do this we must have frequent if not daily baths; it is not enough to wash the hands and face only. This you will understand from what I have said about the structure of the skin and about perspiration. Many houses have a bath-room attached to them, and when such is the case there is no difficulty in having a bath every day. Providing the

bathers are in good health, a cold bath every morning, followed up by rubbing with rough towels, is a most strengthening and delightful tonic to the system.

"To any one unaccustomed to it, however, it is unwise to plunge at first into cold water in winter time. The skin is very sensitive, and the sudden shock to the nerves will cause a dread of cold water in future. The wiser course is to commence with water of a temperature that càn be borne without any discomfort, and then to gradually decrease the temperature. As a rule a temperature of about 77° F. will be found sufficiently cold for most people, summer and winter. Too much time should not be spent over a bath, or we may catch cold. Immediately upon coming out of the bath, a pleasant sensation of warmth ought to be experienced, a feeling which is greatly aided by brisk rubbing with a rough towel. If it is found that a feeling of cold and chilliness remains after bathing, it may be taken for granted that the bath has done more harm than good.

"Cold baths harden the body, and so prevent us from readily 'catching cold', and, moreover, they greatly strengthen the nervous system. They have, what is called, an excellent bracing effect on the system. But cold water does not remove the dirt so well as warm water, so that to ensure thorough cleansing of the skin it is necessary to have a warm bath, with a free use of soap, once a week at least; better still, twice.

"The temperature of a *warm bath* ranges from 98° to 101° F.; and its effect is chiefly to assist the pores in their efforts to cleanse themselves.

"As soon as the skin has been thoroughly cleansed, the addition of a double handful of salt to the water will be found very beneficial. The particles of salt penetrate the skin and gently stimulate it to increased action. It is for this reason that sea-bathing is superior to fresh-water bathing.

"The evening, just before going to bed, is the best time for having a warm bath, because there is some danger of chill if we have to go out after a warm bath. But if after a warm bath you sponge down with cold water, the pores of the skin close and the danger of a chill is thus removed. So if we take this precaution, and it is best to take it even at night, we may have our warm bath at whatever hour of the day suits us best.

"The most thorough way of cleansing the skin is effected by the Turkish bath. The bather, divested of his clothing, enters the hot rooms with a thin sheet thrown loosely round him. Here he reclines upon a marble slab in a dry air, the temperature of which ranges between 130° and 140° F. There may be one or more rooms at a still higher temperature. Usually there is one of 180°, and often another of about 200° F.; whilst the hottest room in some baths is heated to 250° and even higher. The great heat soon makes a copious sweat break out

on the body, and this is allowed to continue for about half an hour.

"The bather is then well rubbed down by an attendant to take off all the loose scarf or outside skin. This is followed by a washing from head to foot with soap and warm water, after which he is put under a shower-bath. At first the water is warm, but by degrees it becomes cooler and cooler until it is quite cold. When the body has been dried, a sheet is lightly thrown over him, and he rests for a time on a couch in the cooling-room before putting on his clothes again.

"Such a bath is not only valuable for cleansing purposes, but it is also an excellent cure for colds and rheumatism. Those persons, however, who suffer from a weak heart should never take Turkish baths without first speaking to a doctor, otherwise the bath may do harm.

"After all, the great point to remember is to keep the body clean, and, I might add, our clothes and houses as well. So far as our health is concerned, nothing but evil can come from dirt."

WHY WE WEAR CLOTHES.

Upon returning from his rounds next morning, the doctor found Harry in a pretty plight. Judging from the appearance of his clothing it was evident

he had been in the wars, and had come off second best.

"How came you to tear your clothes like that?" asked his uncle.

"Arthur and I had a race to see who would be home first; and for a short cut I came through the wood at the back of the Rectory, and tore my clothes in the brambles."

"So it appears," said his uncle. "But have you hurt yourself?"

"Not at all, thank you," replied Harry.

"You need not thank me," said his uncle laughing; "I had nothing to do with it. You have to thank your clothes for saving your skin from injury. Had you belonged to one of the savage tribes who wear no clothes at all, or none worth mentioning, your adventure would have cost you some nasty scratches.

"Before you change your dress we may as well finish our talk about the uses of clothes, since we have made such a good beginning. There is plenty of time before dinner is ready.

"Not only do clothes protect the body from injury, but they serve several other purposes."

"They help to make us warm," put in Arthur, anxious to assist in the lesson.

"You are wrong for once," said his uncle. "You shall shortly see that clothes do not *make* us warm, though they may *keep* us so. When your feet are cold you never think of sitting in front of a heap of

clothes, even if they be blankets, to warm them. If clothes were really warm, I am afraid the tailors' establishments would be the hottest shops in town.

"People say that clothes are warm, because they keep the natural heat of the body from escaping and prevent the cold air from coming in too close contact with the skin. In fact, clothes are to the body what a tea-cosy is to a tea-pot. Covered with the cosy, the tea will keep warm for hours; without one the pot soon gets cold. Of course all clothes do not keep us equally warm. Some are much better than others, as we shall learn in another lesson.


Thermometer.

"That clothes are not warm can be readily proved by the help of a thermometer."

Here the doctor took down the thermometer that was hanging on the study wall.

"You see that the top of the mercury in the tube is level with the number 60. That tells us the degree of heat near the thermometer. I will now wrap it in this piece of flannel and leave it there for a few minutes."

When the thermometer was taken out again, it still stood at 60°—no higher than before.

"Had the flannel been warm," continued the doctor, "the mercury would have risen to a higher point.

"By the aid of two thermometers I can also illustrate the principal use of clothing. First of all I will put the two instruments into boiling water; the mercury in each will rise to the same point,—namely 212°. Then I will take them out and wrap one in the piece of flannel and leave the other uncovered. At the end of ten minutes we will examine the thermometers again to see the result of the experiment."

"I think I know what it will be," said Arthur again. "The one left uncovered will cool quicker than the other."

"You are right this time," said the doctor.

Accordingly the experiment was performed; and it was found that at the end of the ten minutes the one left exposed to the air had gone down to 70°, having parted with most of its heat to the air, while the other stood at 120°; because the flannel prevented a rapid escape of the heat.

"That is exactly what our clothes do for us," the doctor went on. "They prevent the heat of our bodies from escaping too rapidly into the surrounding air.

"As we must allow Harry a little time to dress for dinner, I can only just mention the other uses of clothing. When we go out of the house into the hot sunshine, our clothes keep off the heat of the sun from the skin; so that clothes not only keep in heat, but also keep it out. Lastly, when properly

made, and of good materials, clothes are an ornament to the body, or as a poet expresses it—

"'My Love in her attire doth shew her wit,
It doth so well become her:
For every season she hath dressings fit,
For winter, spring, and summer.
No beauty she doth miss
When all her robes are on.'"

MORE ABOUT CLOTHING.

The first question which the doctor asked at the lesson next day was for the purpose of discovering whether his pupils knew the materials commonly employed for clothing. Now Ethel was like a second mother about the house. Nothing delighted her more than to talk with her mother about what was best to wear, or else to assist in the making of her own garments. So that when the doctor put his question, he was not at all surprised to hear her mention *wool*, *cotton*, *linen*, and several other materials, immediately.

"From the experiments we had yesterday," the doctor continued, "we learned that woollen articles, such as flannel, did not allow heat to pass easily through them. For this reason wool is said to be a bad conductor of heat. *Down* and *furs* are even worse conductors than wool; but they are not suited

for the ordinary purposes of clothing, and are, besides, too expensive for most people.

"Of the materials employed for clothing, wool is by far the most useful and healthful we possess. I have already explained to you that the body is cooled—among other ways—by the evaporation of the perspiration from its surface. After exercise, the body sweats, and you will easily understand that if the evaporation from the skin be very rapid, there is a danger of a too sudden cooling of the body.

"If we could remove the evaporation of the sweat from the surface of the body, where it may prove harmful, to the surface of the clothing, where it is practically harmless, the risk of catching cold would be very considerably reduced. Now certain dress materials, of which wool is one of the best, possess this power of absorbing moisture, and passing it on, as it were, to the surface to allow of its evaporation. Other materials, such as cotton and linen, are wanting in this property; and hence, when they are worn next the skin, they simply become wetted. An individual, therefore, who perspires freely is less likely to catch cold when clothed in wool than when clad in either cotton or linen."

"But," said Arthur, "if our clothes take up the moisture from our bodies so readily, will they not absorb the moisture from the air just as much?"

"Quite so! But the absorption from the air is so trifling, we need not trouble ourselves about it. Hence in such a changeable climate as ours wool should be worn next the skin, both in summer and winter.

"In the winter every one should wear woollen underclothing; knitted wool under-vests, well up to the neck, being the best. In summer the vest may be lighter and more gauzy. If people would only follow a doctor's advice, there would be fewer coughs and colds than there are now. With good woollen underclothing there need be little fear of catching cold in the coldest weather, even—

"'When icicles hang by the wall,
And Dick, the shepherd, blows his nail;
And Tom bears logs into the hall,
And milk comes frozen home in pail'.

"One of the chief objections to cotton or linen clothing is the ease with which it takes fire. This is a matter of great importance to those employed in occupations which constantly bring them in contact with burning materials, such as iron-founding, for example. Now woollen fabrics smoulder rather than break out into flame when set on fire, and it is for this reason that woollen clothing is commonly worn by men engaged in such dangerous trades.

"By means of a simple experiment I can show

you how wool, silk, cotton, and linen behave when heated. Here I have a small piece of each of these dress materials. After placing them upon this thin sheet of the metal *platinum*, I hold them over the flame of the spirit-lamp. See! The cotton and linen pieces burst into flame immediately; while the silk and woollen pieces simply become charred without breaking out into flame.

"It is also a well-known fact that a closely woven cloth is less inflammable than one with open meshes. Thus, if a person's dress is on fire, the flames can be quickly extinguished by closely wrapping the body in a blanket or a woollen shawl. Of the common dress materials, muslin is the most inflammable. Loosely woven, and made of fine cotton thread, it quickly takes fire, and burns with great rapidity.

"The colour of clothing is not of much importance unless we are exposed to the fierce rays of the sun. When the sun's heat falls upon black cloth, it is all absorbed, and the clothing becomes uncomfortably hot. White-coloured cloth only absorbs half as much as black. Hence if you wear a black coat on a sunny day, you feel much hotter than if you wear a light-coloured one.

"The last point of importance I wish to mention about clothing is, that it should not be too heavy, and it should be evenly distributed over the body. Warmth and lightness should always go together; and this explains why those who can afford them

are so fond of furs. But unless the clothing is evenly distributed, it is impossible to maintain an even temperature throughout the body. Usually the middle part of the body is overloaded with clothing, while the limbs and upper part of the chest are altogether too thinly clad.

"Before we disperse, let me repeat the chief points to be borne in mind about clothing. Firstly, it should maintain an even temperature in every part of the body; secondly, it should not interfere with the perspiration; thirdly, it should not easily take fire; fourthly, the weight of the clothing should be distributed evenly over the body; and lastly, as I mentioned in an earlier lesson, not be too tight."

THE DANGERS OF ALCOHOL.

The day was now rapidly drawing near for the two boys to return home, and so far as the talks were concerned the doctor felt that the time had gone altogether too quickly. There were still many topics that he had not touched upon; but as "time and tide wait for no man", he had to console himself with the thought of the work already accomplished, and the hope of continuing it at some future date.

One thing was certain—he could not let his two nephews leave Redcliffe without dealing with what

he believed to be at the root of much of the misery and suffering of the present day. In common with other medical men he was fully convinced that among the many preventible diseases, those produced by intemperance in the use of alcoholic drinks occupy the first position.

To make the lesson more easily understood he

A Match applied to a Saucer containing Alcohol.

had brought from his surgery a bottle containing some alcohol, and fr[illegible] which he had removed the label.

"What do you think I have here?" asked the doctor, as he shook the bottle.

"Water," said Harry, as he saw the bottle.

"Being a thin colourless liquid it does look very much like water, but take the stopper from the bottle and find out for yourself by your nose."

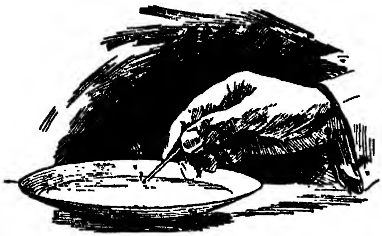
Harry did as he was told, but the first sniff was quite sufficient to satisfy him that it was not water.

"To make certain I will pour a little into this

saucer, and then apply a lighted match to it. At once it bursts into flame, and burns with a pale-blue flame free from smoke.

"Now, Harry, you shall pour some water into this other saucer, and see if you can set that on fire."

Harry struck another match, and held it quite near the water; but there was no bursting into flame this time. He even dropped the lighted match into it, but all to no purpose—the water would not burn.


A Match applied to a Saucer containing Water.

"What you see in this bottle," continued the doctor, "is nearly pure alcohol, a substance which is to be found in, and is the chief element of, beer, wines, and spirits."

"That is the intoxicating portion, is it not?" asked Arthur.

"Yes," said his uncle. "Now alcohol, when taken into the stomach, passes quickly into the blood, and the latter quickly carries it to the brain. The effect upon that organ, if sufficient alcohol has been taken, is to make it lose control over the movements of the body. That is why a person under the influence of alcohol staggers along the pavement in the

manner we too commonly see. His brain is unable to control the muscles of his legs.

"When large quantities of alcohol are consumed the brain may even cease to act, and then the individual falls insensible to the ground, 'dead drunk'. If he is foolish enough to continue drinking, he runs the risk of utterly ruining his health, and dying a miserable death.

"Alcohol also makes the heart beat too quickly, and thus causes it to perform more work than it would otherwise do. In consequence of this increased action of the heart, the flow of blood through the body is quickened, and the blood-vessels are kept fuller than usual. The diameter of the blood-vessels is regulated by the sympathetic nerves of which I spoke in an earlier lesson. Now, on account of the action which alcohol has upon these nerves, the walls of the blood-vessels relax, and the blood-vessels become gorged with blood.

"If this continues, as in the case of the regular tippler, the swelling of the blood-vessels becomes permanent, and then the blood within them does not flow along as evenly as it ought to do. Hence the redness or flushing of the skin is the outward sign of the mischief which the alcohol is doing within the body."

"You also told us the other day that the use of alcohol was often a cause of indigestion," said Arthur. "That is another black mark against it."

"Yes, the immoderate use of alcohol hinders digestion in two ways. Here, for instance, I have a little white of egg which has been kept in spirit; you see how hard it has become. Instead of dissolving it, as water would have done, the alcohol actually preserves it. That is the very reason why alcohol is used in museums to preserve animal substances. Even supposing it did not harden the food as we have seen, the effect of alcohol upon the stomach is such that the flow of gastric juice is checked, and consequently digestion is either partly or entirely stopped.

"One of the chief organs to suffer from the free use of alcohol is the liver. The structure of this organ is so altered that it is impossible for the blood to flow properly through it; consequently liver complaints are a constant trouble to people of intemperate habits."

"But in winter people take it to make them warm, do they not?" asked Arthur.

"Yes; but it does nothing of the kind. Cold is better endured by the abstainer than by the drinker. For a very short time, it is true, a person feels warmer after taking a little alcohol, but this is simply due to the rush of blood to the skin. The feeling of warmth, however, quickly passes away, and the body is really left colder than it was before the spirits were taken.

"I have only spoken of a few of the terrible

effects of intemperance; it steals away health, disturbs the brain, leads to poverty and crime, and shortens life."

Thus ended the last of the talks with the young folks for the present. The doctor would have liked to have continued them, but it was impossible. His two nephews had to be home before the end of the week, ready to commence the next session at the new Technical School.

PART II.—THE DWELLING.

THE SITE OF THE DWELLING.

With very mixed feelings the two boys returned to their home. While sorry to leave Redcliffe, they were delighted at the thought of meeting their parents again.

Little, however, did they dream that a pleasant surprise was in store for them. Both had fully made up their minds that the talks with their uncle were not likely to be resumed before another holiday arrived; but in this idea they were mistaken as they soon found. The medical officer of the town in which the Cottrells lived had resigned, and to the joy of his nephews their uncle had been appointed in his stead. And so it came to pass that, as soon as the doctor was settled in his new home, arrangements were made for his two nephews to meet him on Saturday afternoons until the talks were ended.

The first Talk of the new course was devoted to the choice of a site for a dwelling, because this is one of the most important points to be considered by anyone about to build. A fault in the house itself might possibly be remedied, but if it is built in a wrong place very little can be done to make it healthy.

"In choosing a *site*," said the doctor, "special attention should be paid to the *nature of the soil* and the situation of the land upon which it is proposed to build. Pervious soils, such as gravel, sand, and chalk, are always healthy except when they lie below the level of the surrounding land. In that case they are likely to become water-logged, especially if there is a bed of clay beneath them. Clayey ground, unless it can be properly drained, should always be avoided, as it is sure to be very damp. The influence which a dry soil has upon health has been strikingly shown in several instances in our country. Of the diseases known to be closely connected with damp soil, consumption is the chief; and in those places where a thorough system of subsoil drainage has been effected, the death-roll from this disease alone has been thereby reduced by fully one-half. Rheumatism and 'colds' are also known to be caused through living in houses erected in damp ground.

"The best situation for a house is on rising ground. We may occasionally find people selecting a low-lying part in the belief that such a spot is sheltered, but this is a great mistake. Not only would such a site be difficult to drain properly, but experience proves that the winds may beat down upon it quite as much as if it were at a greater elevation.

"Another most unhealthy soil is that commonly

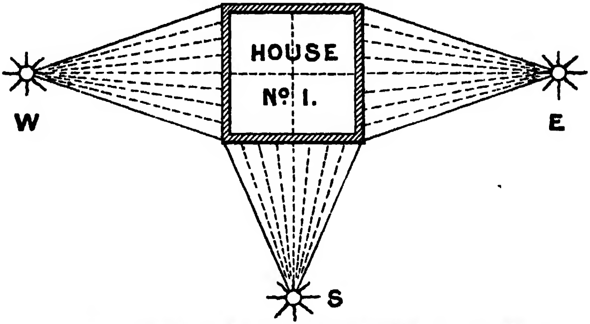
known as 'made soil'. In districts where sand and gravel are plentiful, it frequently happens that they are carted away and sold for building and other purposes. The huge holes thus formed by their removal are afterwards filled up with the contents of ashpits, road-sweepings, and all kinds of animal and vegetable refuse in order to level the surface once more. When houses are erected upon such ground the heat of the fires in the rooms draws up the foul gases which the decaying materials give off, and serious diseases such as diphtheria are very liable to break out among the inhabitants.

"The next point to remember is that the site should be *airy*. By this I mean that the houses should not be hemmed in by any hills, trees, or high buildings in such a way as to prevent the free access of sun and air. Unless there is a free circulation of air about our houses we can never expect them to be dry. For a similar reason the houses in large towns should never be built 'back to back', but always in wide streets, with plenty of space between the two rows.

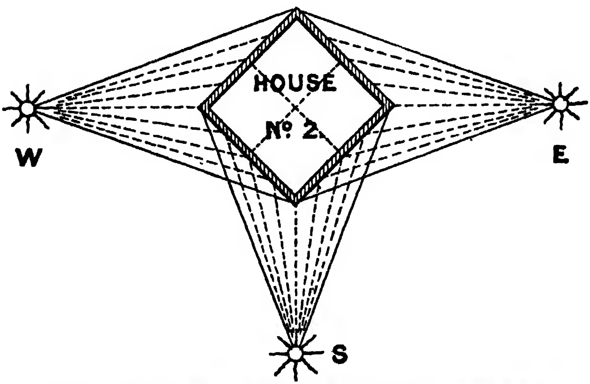
"Another point which must not be overlooked is the *distance of the water supply*. In towns the water is brought to the houses by pipes, and little difficulty is experienced about a good supply of water; but in country places it is quite different. We have, then, in choosing a site, to consider the distance of the nearest spring or water-course, or

to discover whether the rocks beneath are water-bearing strata or not.

"The last point I need dwell upon is the aspect



Plan of House with sides facing the cardinal points of the compass. North side never receives any sun.



Plan of House with corners facing the cardinal points of the compass. All the sides receive sunshine.

of the house. This should be such that the house can receive plenty of sunlight, and yet not be exposed to the biting bleak winds from the east

and north-east which are so prevalent in the winter and early spring. I can illustrate this part of my subject by means of this plan of a square house. When the sides of the house face the four cardinal points of the compass, the one on the north side would never get any sunshine at all; but by setting the corners to the four points of the compass, the sun would shine into every room during some portion of the day.

A VISIT TO A NEW HOUSE.

Upon questions dealing with the sanitary construction of houses, the two boys received great assistance from their father, who was a builder of considerable repute in his native town. Just then he was engaged in building a large house for a gentleman in one of the suburbs; and it occurred to him that it would be an excellent plan to take his two boys with him next Saturday morning, when he went to pay his workmen their weekly wages. In that way they would get a more practical insight into the healthy construction of houses than all the printed books upon the subject could give.

As they drove through the town in the builder's trap, he explained to his boys that it was always the wisest policy, when building a house, to employ only the very best materials in its construction; for,

as he said, "the best is always the cheapest in the end".

"I always make it a point never to use second-rate materials, such as many of the 'jerry' builders use in most of our large towns. I have seen house-drains made of pipes which I would never dream of using; because I am too well acquainted with dangers arising from defective or unsound drain-pipes.

"Take the wood-work again in many of the cheaper class of houses. Too often the wood employed is green, practically fresh from the trees; and when the house has been occupied for a few months the wood shrinks, and ugly spaces, in which all kinds of filth can collect, appear between the boards of the floor. The doors and window frames also shrink to such an extent that they rattle with the least breeze.

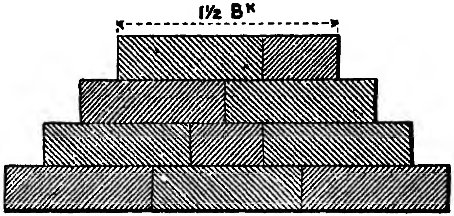
"Every bit of timber I put into a house is thoroughly seasoned. Some of the wood I have under cover in the yard has been there for several years, and it is now as dry as a bone. It cannot shrink any more; and when I make a floor with it, I will guarantee that you will not get the blade of a knife between the boards."

When they arrived at the new house, all the workmen were busily employed. Some were mixing the lime and sand together, and wetting them with water to make mortar for the bricklayers; others—the stone-masons—were dressing the stone work;

and the carpenters were hard at work, in a shed at the back, making the window-frames and door-jambs so as to be ready when they should be required.

"I see you have made a good foundation, father," said Arthur.

"Yes; with substantial walls and a firm foundation there is not much fear of your house tumbling



Footing for Foundation Wall.

down like a pack of cards. When we commenced digging for a foundation, we made the men excavate the ground until they reached the solid rock beneath. Then we had a bed of concrete, about eighteen inches thick, laid all under the house. By doing that, we not only give the walls something firm to rest upon, but we keep the moisture and ground-air in the soil from rising into the walls and rooms above."

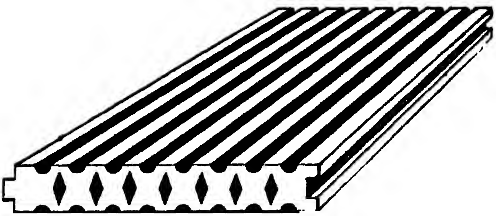
"But how thick you have made the walls at the bottom!" said Harry.

"Yes," said his father. "I took a lesson from our friend the camel. His feet, you know, are so large and broad, that when he walks on the loose

sand, he does not sink into it, as a horse would do. So by making the foundation walls thick at the bottom, there is less chance of their settling when the house is finished."

"And what are all those holes in the walls for?" asked Harry.

"I will tell you," said his father. "You know



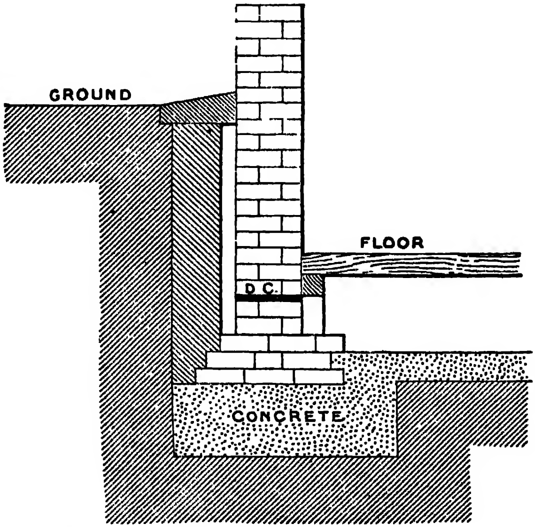
Perforated Stoneware Tile.

that bricks and stone are porous. If you dip the corner of a lump of sugar into tea, the liquid will instantly rise and spread all through the sugar. In the same way bricks and stone suck up the water from the ground in which they are placed; and unless something is done to prevent it, the water will rise into the walls above and so make them damp.

"One very good way of preventing this is to lay a *damp-proof* course along the top of the walls where they come to the level of the ground. Several materials are suitable for making a damp-proof course. Slate, sheet-lead, asphalte, or glazed tiles are the commonest. I have used glazed tiles, although sheet-lead is equally good; and the holes

you speak about are in these tiles. They are for letting fresh air pass through to the space beneath the floors.

"But the gentleman for whom I am building the



Section of Wall, showing Concrete Foundation, Damp-proof Course, Dry Area, &c.

house is so afraid of rheumatism, that I have been compelled to take an extra precaution to keep his house dry. This is by means of what we call a dry area. It is simply a space of sufficient width to keep the damp soil away from the walls, and covered in at the top, except at a few points where openings are left for the air to pass in and out.

"But I must now pay the men, and as you have

seen all I have to show you to-day, we can turn our faces homewards. When the house is further advanced you shall come up again to see it."

THE PRINCIPLES OF VENTILATION.

"In one of our talks at Redcliffe," said the doctor at the next meeting, "I explained to you the changes produced in the air by the respiration of human beings, and the injurious effects arising from breathing a vitiated atmosphere. Now the object of *ventilation* is to make the air indoors resemble as nearly as possible that out of doors, taking care of course not to create a draught. Both of you know what a draught is, I suppose."

"Oh, yes," said Arthur. "It is a cold current of air entering a room at one point and flowing out at another."

"Quite right; but before dealing with the several methods of ventilating our rooms, I must point out to you some facts about the composition of the atmosphere which I purposely omitted in our former chats.

"Now the most curious thing in connection with the composition of the air is this: although the atmosphere is being continually robbed of its life-supporting oxygen, and constantly fouled by carbonic acid gas and other matters, yet when we

come to examine the air in open spaces we find that its composition is always the same. Anyone would naturally think that the oxygen would in time be all used up, and the carbonic acid gas increased to such an extent, that we should not be able to live any longer. This, however, is not so; the air is as pure to-day as it was yesterday, or the day before, or a year ago, or a hundred years ago.

"'How do we account for that?' is the question which most of you are probably asking yourselves. It was Dr. Joseph Priestley who first gave us the answer to the question. He showed, by one of the most beautiful experiments we can perform, that the purity of the atmosphere was maintained chiefly by the action of every leaf that grows. With a needle I will detach from the underside of this leaf a small portion of its skin; and, after pressing it gently upon a slip of glass, you can examine it under the microscope."

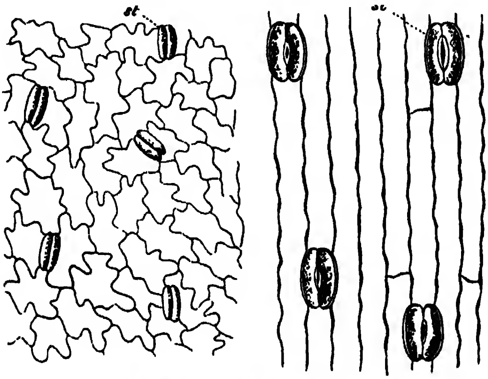
Here is what the boys saw. Scattered all over the surface of the leaf were numerous tiny openings, somewhat resembling the letter O in shape.

"These openings," said their uncle, "are the pores or mouths of the leaf-skin, and are called *stomates.*

"By means of these stomates it is found that plants, whilst exposed to the sunlight, take in the carbonic acid gas from the air; and once this gas is absorbed by the leaves it undergoes a change there through the aid of the sunlight and the green

colouring matter of the leaves. The carbonic acid gas, in fact, is decomposed into its elements, carbon and oxygen. The carbon is retained by the plants to build up their various parts, and the oxygen, not being wanted, is returned to the air.

"That such is the case we may prove for our-

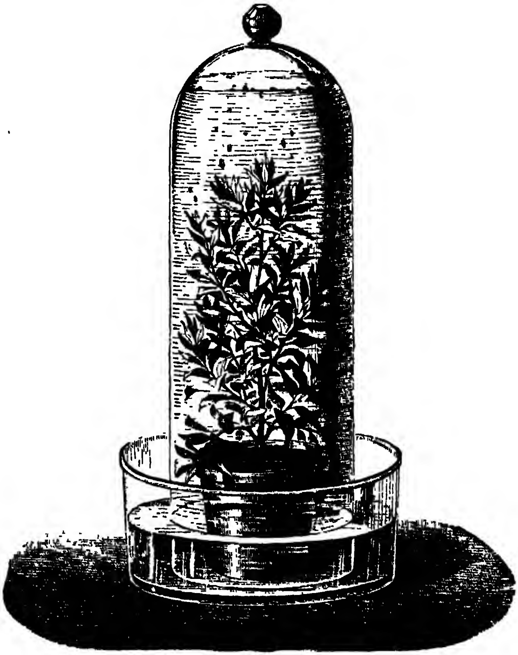


Surface View of Epidermis. *st*, Stomata.

selves as Priestley did. A tall glass jar is first of all filled with water, containing carbonic acid gas in solution. A handful of mint or a living plant is put into the jar, which is then placed in a glass basin partly filled with water. If the sun be now allowed to shine upon the plant for a few hours, we shall see, if we have the patience to wait, bubbles of gas rising from the leaves to the top of the jar, and so pushing the water out into the basin.

"If I now plunge a glowing match into the gas

thus obtained, it will be found to be pure oxygen. During the time the plant is in the water, it feeds upon the carbonic acid gas; and, in doing so,



Disengagement of Oxygen under Water.

separates the two elements—carbon and oxygen—of which this gas is composed. The carbon, as I say, is kept by the plant to build up its body and leaves, while the oxygen is set free in the water.

"If a somewhat similar experiment be performed in darkness, bubbles of gas will also rise from the

leaves; but in this case the gas will be found to be carbonic acid gas. Plants, in fact, at night time, respire as we do. They take in oxygen and send out carbonic acid gas."

"Then, according to what you say," said Arthur, "it must be unhealthy to keep plants in a bed-room."

"Of course, strictly speaking, it must be; but the amount of carbonic acid gas exhaled by a plant is so exceedingly small, that we need not apprehend any danger from a plant in a bed-room.

"Lastly, the rain also assists in purifying the atmosphere, partly by removing a little of the carbonic acid gas, but more especially by removing the solid particles like dust and soot. In fact, it *washes* the air."

HOW THE AIR IS SET IN MOTION.

"From what I have already said, you will understand that air which has been breathed once is not fit to breathe again; and unless we are prepared to suffer from headaches, and run our chances of getting lung diseases in some form or other, it must be perfectly clear to you that we must somehow introduce air currents into our rooms, which will not only remove the impure air, but also bring fresh air to replace it.

"It should be borne in mind, however, that this

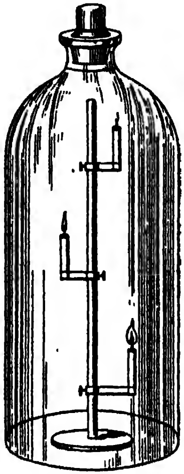
change of the air ought to be done in such a way as not to be felt by us. If we feel the changing currents—feel a *draught*, as we say,—there is a risk of our taking cold.

"In order to ventilate a room properly, it is necessary to make, in the proper places, openings large enough for the foul air to pass out; and other openings, also in the proper places, large enough to let fresh air in. These openings should, as far as possible, be in addition to the doors and windows; though the latter are the only means of ventilating the majority of houses.

"It is a familiar fact to all of us, that the steam which issues from the spout of the kettle rises upwards; and it does so because it is lighter than the air. Heated air is lighter than cold air, and hence always rises to the upper parts of the room. By way of illustrating this point, and of proving the ascension of a gas when heated, I will perform a simple experiment.

"Here, I have three candles fixed at different levels on a central stalk. Having lighted the candles, I place over them a glass jar, so that the air cannot get in or out. If we watch the three flames we shall see that they behave differently. As the candles burn away, carbonic acid gas is produced, and, although a very heavy gas when cold, it now rises to the top of the jar on account of its being warmed. The flames soon show signs of distress,

and the uppermost one quickly goes out; the carbonic acid gas has extinguished it. The middle one also follows, while the lowest one is at the point of going out. Before it does so, watch the effect of making an inlet for the cool fresh air to flow in below by tilting the jar, and an outlet for the heated impure air to escape by removing the stopper. Instantly the flame is revived, and continues to burn brightly.

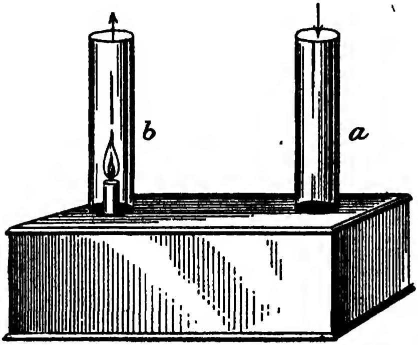


Combustion in a Closed Jar to prove that heated impure air ascends.

"It is clear from this experiment that the air has been set in motion by the heat of the burning candle; and simple as it may appear, it illustrates what is continually going on around us on a larger scale. Whenever a fire is lighted, there is set up a motion in the surrounding air, and it is largely by this means that our rooms are ventilated. The air above the fire is heated, and so made lighter than the air in the room. Consequently it rises up the chimney, and more air must enter the room to take its place. If no special inlets are provided—and, unfortunately, they are absent in most houses—the fresh air is drawn in through the chinks of the windows, round the doors, and even between the flooring-boards.

"In this way our fires maintain a constant current of air up the chimney, and an inflow of fresh air from

the outside of our dwellings. By the aid of another experiment this circulation of air can be plainly shown. Here is a small air-tight box which has two round holes in one of the sides, one near each end. Into each of these is fitted a glass chimney. At the bottom of the chimney *b* I will place a lighted candle; and as long as the chimney *a* remains open, the candle in *b* continues to burn brightly. If I now hold a smouldering piece of brown paper over the mouth of the chimney *a*, the smoke from the paper will be seen streaming rapidly down into the box, and out at the other chimney, thus clearly showing which way the air is moving. By placing the hand flat on the top of *a*, so as to prevent the entrance of the air, the candle will speedily go out.



A Simple means of Showing the Necessity for Inlets and Outlets.

"This experiment will also illustrate the method of ventilating mines, largely employed until recent years. At the bottom of one of the shafts, used as a chimney, and called the up-cast shaft, a large fire was kept burning. This made the air in the shaft rise upwards, while the fresh air was admitted down

the other one, called the down-cast shaft. Thus the men in the underground workings were continually supplied with fresh air.

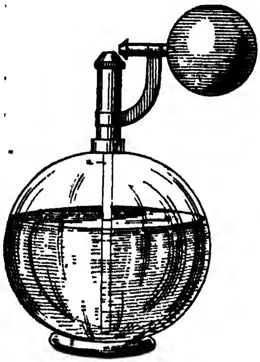
"Now, what do these experiments teach us? It is this: that whether the air is used-up by human beings or by fires and lights, it must be quickly got rid of, and replaced by fresh air; and to effect this change two openings at least are necessary, one for the escape of the foul air, and another for the entry of fresh air."

METHODS OF VENTILATION.

"Speaking of a chimney reminds me of a practice which is very common in summer-time when fires are not required in most of the rooms. Many persons are in the habit of blocking up the chimney with a bag of shavings or a bundle of worn-out clothes. The bed-room chimney in particular is very often treated in this way. Now when we remember that the chimney is generally the only outlet for bed-rooms, we shall understand how foul the air must become. There is no wonder that the occupants of such rooms often wake in the morning with headache, and feel but little refreshed by the night's repose.

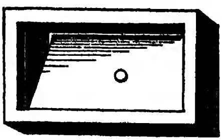
"Even when there is no fire, a steady current of air is always passing up the chimney. This is due to the action of the wind, which draws the air out

of the chimney as it blows across the top. I can illustrate this action of the wind upon the air in the chimney by means of this scent-sprayer. It is generally made with an india-rubber ball to cause a wind to blow across the top of the small glass tube which dips into the scent. Each time the ball is pressed the scent is drawn up the tube and driven out as a fine spray. Now this is exactly what happens when the wind blows over a chimney, except that the air takes the place of the scent.



A Scent-sprayer.

"The chimney, however, cannot be said to do all that is required for the removal of the foul air. At night, when gas is burnt and the room is occupied by a number of people, much of the impure air will remain near the ceiling, as you can find out by getting on a high chair or on a pair of steps in the room during the evening.

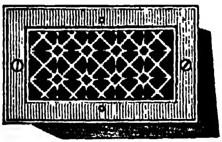


Dr. Arnott's Valve.

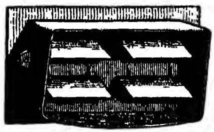
"To get rid of this foul layer, *Dr. Neil Arnott* invented a *chimney-valve*. An opening is made near the ceiling through the wall into the chimney, and in this is fixed an iron box having a light metal lid or valve so arranged that

the air can pass from the room into the chimney, but not from the chimney into the room. The great drawback to this form of ventilator is the disagreeable clicking noise which is made each time the valve closes.

"To correct this defect, *Boyle* improved upon Arnott's valve by using thin sheets of a mineral called *mica* instead of metal for the valves. The



Mica-flap Outlet Ventilator (front view).



Ventilator (back view).

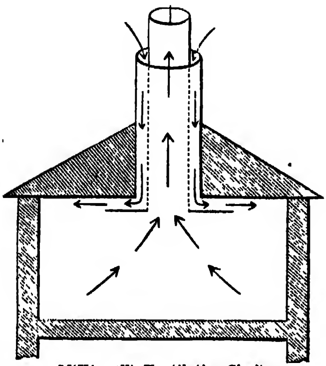
mica flaps swing on iron rods which run across the back of the ventilator; and as they are so very light, the slightest current of air will push them open and thus escape into the chimney."

"But with such arrangements as these," said Arthur, "is there not a danger of particles of soot and smoke from the chimney coming into the room?"

"Oh, yes; and I must admit at once that such is the case whenever they happen to get out of order. So long as there is nothing wrong with them, they do their work very well; but still they are open to that one objection.

"The best plan is to have a separate smaller flue built in the wall alongside the chimney, but not communicating with it. Openings can then be made

through the wall near the ceiling in each room into this shaft. The heat of the ordinary chimney keeps the smaller flue. warm and causes a draught in it, which thus draws all the foul air from each room in turn.


M'Kinnell's Ventilating Shaft.

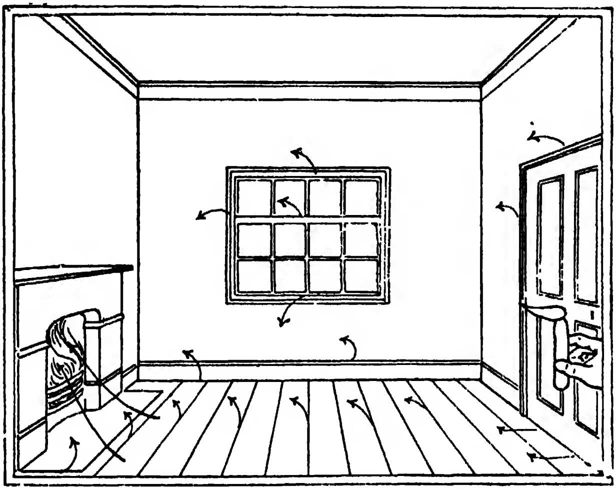
"For small rooms the ventilator employed by M'Kinnell is very suitable. In this there are two tubes, one inside the other, both opening at their lower ends in the ceiling of the room. The inner tube is longer than the outer one, and is the shaft by which the foul air escapes. The fresh air passes down the outer tube, but is prevented from falling directly to the floor by means of a broad rim or flange at the bottom of the tube.

"It is now found that there is no necessity to have one tube inside another. If two pipes of unequal lengths are placed in different parts of the room the same purpose is served."

SOME MORE VENTILATORS.

"We have considered how best to get rid of the foul air in our rooms, and must now pass to

consider the best means of admitting fresh air. If there are no special arrangements for ventilation, the great draught up the chimney causes air to enter the room through all the cracks and crevices that



The presence of draughts in a room; shown by candle-flame at keyhole. (After Teale.)

may exist. A simple experiment will quickly prove that this is so. If, when a fire is burning in a room, and the doors and windows are closed, we hold the flame of a candle in front of the key-hole, or any other opening that may exist, the air will be found to rush in, perhaps with sufficient strength to blow the light out.

"If you but think for a moment, you will see that there is here a source of considerable danger. What we want to obtain is a supply of the purest

air possible; but if we feed our rooms with the air from the passages, cellars, and other parts of the house, we shall certainly not succeed in getting the kind of air we desire. To simply substitute one bad servant for another equally bad leaves us no better off than we were.

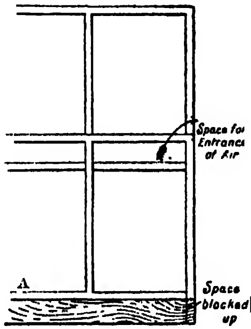
"In order, therefore, to prevent the air entering by these channels, other means must be taken for admitting it. First on my list stands the window. This is without doubt a splendid ventilator—if you can get it open. In every house attention should be given to the sashes, to see they are kept in good working order, so that they can be easily lowered or raised.

"If the top sash be lowered and the bottom one raised, the warmer impure air passes out of the room through the space at the top, and the cooler fresh air flows in through the space at the bottom. As soon as we are ready to leave the bed-room in the morning, the windows should be thrown open in this way as far as possible, so as to allow the air to flush the room thoroughly. In living-rooms, such a method cannot be tolerated, except, perhaps, in the summer months, on account of the draughts.

"One of the simplest ways of admitting air by the window is that recommended some years ago by *Dr. Hinckes Bird*, and called by him 'costless ventilation'. It consists in raising the lower sash, and inserting beneath it a piece of wood as long as

the window is wide, and about three inches deep. A space is thus left between the two sashes, through which the air passes into the room; and since it enters in an upward direction, no draught will be felt. The chief objection to this method is that in large towns 'blacks' are carried in by the entering air.

"But since the sight of a ventilator or an open window makes some nervous people afraid of draughts, the following plan is to be recommended. A number of slits may be cut between the two sashes, or several holes drilled, so that the air can enter while the window is shut. By filling the openings thus made with cotton wool, the incoming air will be filtered and freed of all particles of soot and dust.

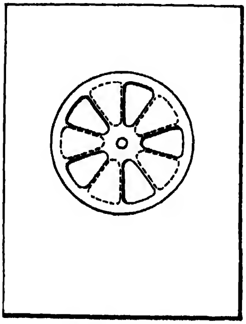


How to Ventilate a Room. A, Front view of window; B, Side view, c, c', Ventilating board.

"Some windows are provided with Venetian blinds, and, when such is the case, these can be easily made to act as inlet ventilators. The upper window-sash is first pulled down, then the blind is lowered and the laths made to slope from the window upwards into the room. The air entering between the up-turned laths is thus directed upwards towards the ceiling. What are called *Louvre ventilators* closely resemble these blinds in their

construction. Instead of a single pane of glass, several strips of glass, lying one over the other, are fixed in a frame in such a manner that they can be easily opened or closed at will.

"Before passing from the window to the other forms of inlet ventilators, I should like to say a word about *Cooper's ventilator*, which is still to be met with in many country places. One of the panes in the window has five oval holes cut in it, and in front of these there revolves on a central pivot a circular piece of glass having five similar holes. When it is desired to let fresh air in, the disc is turned round until the holes in the two sheets of glass coincide; by giving it a further turn the openings of the one will be brought between the openings of the other, thus closing the ventilator. But this form of ventilator is always draughty, and is not to be recommended."

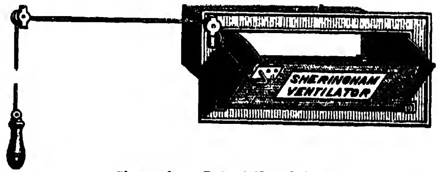


Cooper's Ventilator.

MORE AIR.

"Passing next to those ventilators which are specially made for the admission of fresh air, two very good ones may be mentioned. The first is

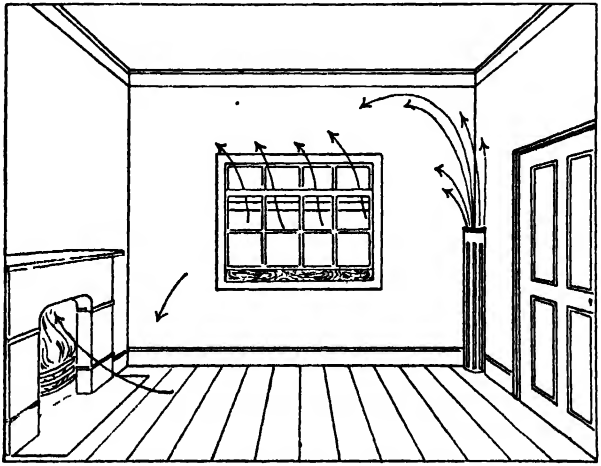
known as the *Sheringham Valve.* It is simple in construction, and can be conveniently fixed in the wall of a room, so as to communicate with the outer air through an iron grating. It consists of an iron box which fits into a hole cut in the wall, and to its lower edge is hinged a lid or valve which can be opened or closed at will. As the fresh air enters the room, it strikes against the inside of the lid and is thus caused to rise towards the ceiling. It then gradually sinks downwards and becomes mixed with the air of the room. By means of the cord, which is attached, the width of the inlet may be altered at pleasure; and in windy weather, the valve can be shut quite close.



Sheringham Patent Ventilator.

"Now the question arises as to which is the best position for an inlet-ventilator. We know that the air out of doors is cooler and heavier than the air indoors; and it is only natural to infer that the fresh air should be admitted on a level with the floor. In warm weather the incoming air may be allowed to enter at the floor-level; but in winter, unless the air is warmed before entering, it would certainly give rise to cold feet. And it is unwise to neglect the excellent advice which warns us to 'Keep the feet warm and the head cool'. On the

whole, the best position for inlet-ventilators is from seven to eight feet from the floor; and it is better to have several inlets at different points in the room than to have the whole inlet space combined



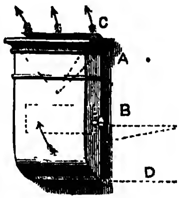
Air entering Room between Window Sashes and through Vertical Tubes. (After Teale.)

in one opening, because the fresh air is thus better distributed throughout the room.

"The second ventilator I wish to mention is that introduced by Mr. Tobin of Leeds, and known as *Tobin's Tubes.* These tubes are the simplest and probably the best of inlet-ventilators. Each tube is shaped like the letter L, the short arm running through the wall and ending in the outer air, and the long arm being carried up against the inside

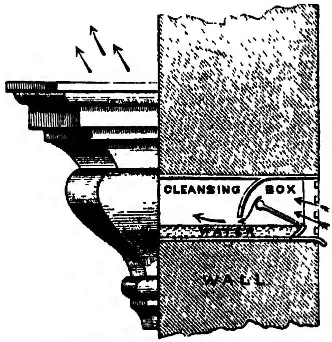
wall of the room for a height of six or eight feet. In the tube is a valve by which it can be closed when not required.

"With these tubes in use no draught is felt, and if it is desired, the incoming air can be easily warmed in such a manner as to leave its purity unaffected. To prevent the particles of dust and soot entering the room, one form of this ventilator has a tray of water placed in it, as you see in this diagram. In this case the Tobin-tube makes an ornamental wall-bracket.



Wall Bracket Inlet on Tobin's System.

Section of Wall Bracket Inlet.



Ornamental Wall Bracket Inlet Ventilator, with Arrangement for Purifying the Entering Air.

"Attempts have also been made to admit fresh air through bricks of special construction. These have conical-shaped holes passing through them. The holes are small on the outside and much wider on the inside, the idea being to make the entering air spread out in order to avoid a draught. The experience, however, of most people is that they are always draughty.

"Hitherto I have spoken principally about the means of ventilating dwelling-houses; for large buildings, such as the Houses of Parliament, hospitals, and theatres, these methods are altogether unsuitable. For such places it is necessary to resort to what is known as 'artificial ventilation', that is, ventilation in which the air is either driven into a building or else withdrawn by the aid of machinery. In either method the air is set in motion by means of strong metal fans which are made to revolve at a great pace by an engine. Of the two, driving the air into the building is without doubt the better plan, though it costs more; you are always certain that fresh air is being sent into the room, and you have full control over the supply.

"Where this method is adopted the incoming air may be washed and either warmed or cooled according to the season of the year. One of the ways by which this is done is to make the air pass through what may be called an artificial shower of rain. A huge frame is fitted with a great number of vertical strings, down which water is constantly trickling, the water being warmed in cold weather and cooled in hot weather.

"Before the fresh air is admitted into the rooms, it is first made to pass through this string-work arrangement; so that it is not only freed from dust, but also warmed or cooled according to the temperature of the water trickling down the strings.

"Such, then, are some of the chief ways by which we can renew the supply of fresh air in our buildings."

WARMING THE DWELLING.

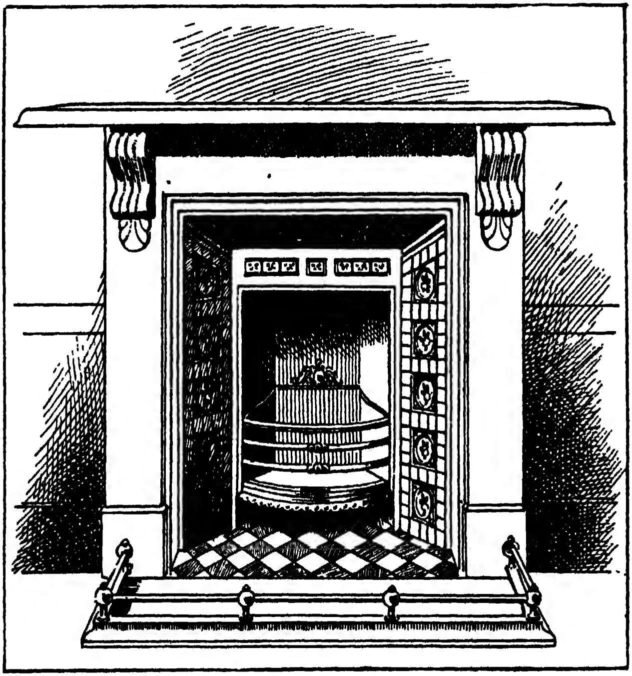
Having disposed of the several methods of ventilation, the doctor then proceeded to enlighten his nephews upon the subject of warming the dwelling, a question which was pointed out to them as being closely associated with ventilation.

"The best temperature," continued the doctor, "for ordinary inhabited rooms is about 60° or 63° F.; and if it falls much below this point we at once begin to feel cold. Whenever a hot body is surrounded by colder ones, the former always gives up some of its heat to the latter. Now, if the temperature of our bodies were the same as that of the air of a room, we should suffer no loss of heat; but since the surrounding air in winter is so much colder than our bodies it follows that we must part with some of our heat to the air. Hence the need of warming our houses.

"Of the many ways by which this is accomplished, the 'open fire' still finds favour amongst the greatest number, on account of its cheerfulness; and it is certainly a most healthy way of warming a room. You remember what I have already told

you about the way in which an ordinary open fire-place acts in ventilating our rooms."

"I certainly like the open fires," said Arthur;



Modern Tiled Fire-grate.

"but I often hear mother complain about the dirt they make and how very wasteful they are."

"Yes; for those reasons the open fire is objectionable. In these days of dear coals it is a most extravagant way of warming and ventilating a room. It has been calculated that about 5-8ths of the heat

from the burning coal is lost up the chimney. Just picture in your mind the enormous quantity of coal which is thus being burnt yearly for no useful purpose at all. The fault lies partly with the manner in which the fireplaces are constructed. Of course a certain amount of heat must always pass up the chimney; but if the fireplace is wrongly built we must expect to lose a great deal more.

"In the first place, the position of the fireplace is a matter of importance. Very often the fireplace is placed against an external wall, in which case a considerable amount of heat is lost by being conducted through the wall to the outer air; but by building it against an inner wall the loss of heat from this cause can be avoided.

"The fireplace should also stand well out into the room, and as much brickwork as possible should be employed in its construction. The sides are sometimes covered with polished iron with the object of reflecting the heat into the room; but for this purpose the glazed tiles now coming into general use are much superior.

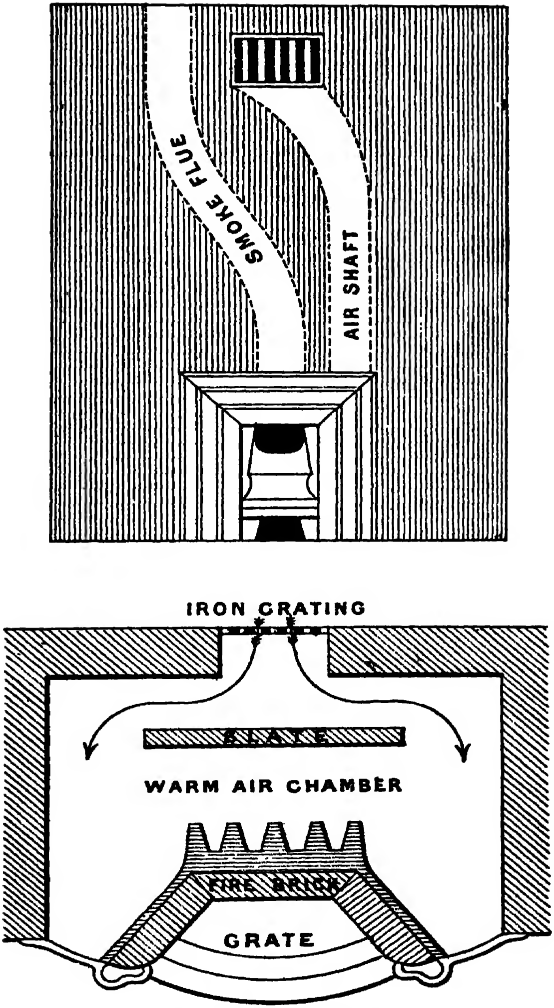
"The shape of the grate is also important. It should be wide in the front and narrow at the back. In fact the back should be about one-third the width of the front, while the depth should equal the width of the back. The sides and back of the grate should be made of fire-bricks, as these soon become red hot, and send the heat into the room instead of

conducting it up the chimney, as iron would do. The back should also be made to lean or arch over the fire.

"Of course, in the selection of the grates for houses the majority of tenants have no choice, and consequently they have to be contented with the kind which the builder has provided. Still, even with the worst form of grate, a considerable improvement can be made by cutting off some of the cold air which too commonly rushes through the fire and carries away with it much of the heat from the burning coal.

"One way of doing this is by having the bottom of the grate made of fire-brick, instead of the ordinary grating; or by closing the space beneath the grate by means of a close-fitting shield or door, which any ironmonger could make. Or, if the expense of these methods be objected to, the bottom of the grate may be covered with an iron plate. In either case the air is prevented from entering the fire from below, and is made to pass between the front bars. By such simple means as these, a saving of fuel is effected, and the bright glowing part of the fire faces towards the room.

"If I ever build a house for myself I shall take care to put in what is called the *Galton grate.* This is an improved form of open grate by which the fresh air for ventilating purposes may be warmed before entering the room. At the back of the grate



Plan and Elevation of Galton Grate.

is an air-chamber which communicates by means of an iron grating with the outer air. Fresh air enters this chamber, and after being warmed by the heated sides of the grate and flue, passes up an air-shaft which opens into the upper part of the room over the mantel-piece. The air-chamber and its shaft are completely shut off from the grate and chimney, so that no impurities can possibly enter the room."

CONCERNING STOVES.

At the next afternoon's talk, the ordinary iron stoves for burning coal were spoken of by the doctor. These, he said, were very economical, and gave out a great heat; but they were not so cheerful as the open fire, and of little help in ventilation.

"Besides, they are very dangerous where there are young children, and I have always found that they create a most unpleasant smell. They may do very well for halls and passages where there is a free circulation of air, but they cannot be healthful in our living rooms unless the ventilation arrangements are more perfect than they are generally to be found.

"The greatest objection I can see to iron stoves is that they help to produce a very poisonous gas called *carbonic oxide*, which is even worse than its near relative, carbonic acid gas.

"To understand how this carbonic oxide is formed in a stove, you must first of all remember that there are two important oxides of carbon,—the one known to you as *carbonic acid gas* and represented by the formula CO_2, and the other, *carbonic oxide*, whose formula is CO. In the one case the carbon is combined with two parts of oxygen, and in the other with only one part. When any form of carbon, such as coke or charcoal, is burnt in plenty of oxygen, each part of carbon combines with two of oxygen to form carbonic acid gas; but if the supply of oxygen is limited, as when coke is burnt in a closed stove, then each part of carbon unites with only one part of oxygen, thus forming the poisonous carbonic oxide.

"Moreover, it is said that carbonic acid gas is actually changed into carbonic oxide by the action of the iron. This, however, would only take place when the stove was overheated; but this is just what frequently happens to stoves made of iron. Now, when iron becomes red-hot it is believed to have the power of converting the carbonic acid gas of the air to carbonic oxide, by taking up a portion of its oxygen.

"If such be the case, then we must take care that the stoves do not reach too high a temperature; and one way of doing this is to have the stoves lined inside with fire-brick, and covered with porcelain tiles, as in some of the German stoves.

"From numerous experiments, it is now certain that when iron stoves are overheated, some of the products of combustion are liable to pass through the iron-work and escape into the room. This would certainly happen if the stoves were badly made, or if there happened to be any cracks in them.

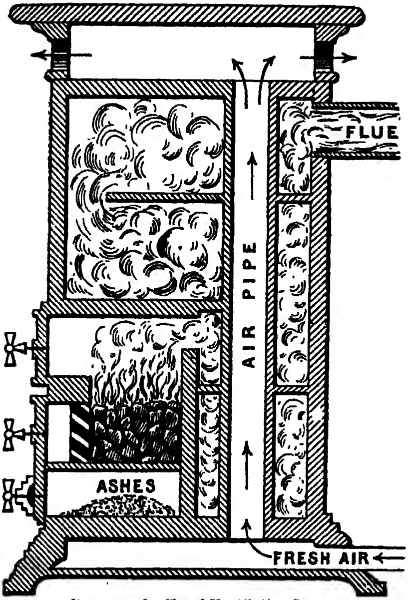


Diagram of a Closed Ventilating Stove.

"There is another feature about iron stoves which I may mention," said the doctor. "The air in a room heated by a stove is apt to become too dry for comfortable breathing. It then causes a disagreeable tickling sensation in the throat. The fault can be easily remedied by keeping a saucer of water on or near the stove, when the evaporation of the water would make the air of the room sufficiently moist. Some stoves which I saw in an ironmonger's shop the other day had a kind of cup or goblet fixed at the top for the very purpose of holding water.

"Of late years, considerable attention has been

given to closed stoves, and several improvements in their construction have been the result. In one of these improved stoves a pipe passes through the stove; one end of it opens through the wall into the outer air, and the other in the room, just above the stove. When the fire is lighted, the air-pipe becomes warm, and the air within it at once rises into the room, whilst more fresh air from outside moves in to take its place, and so on. Thus, as long as the fire is burning, a current of fresh air which is immediately warmed continually flows into the room.

"In many places steps have been taken to employ coal-gas for heating.

"I can illustrate the kind of burners employed for this purpose with the help of this small gas-stove which your aunt keeps for summer use. The

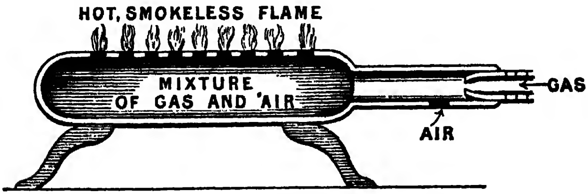
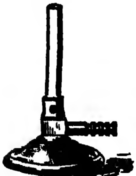


Diagram of Bunsen Burner used in Gas Stove.

ordinary gas-burners are very smoky; and a German chemist named Bunsen found that if the gas was mixed with air before it was burnt, a very hot smokeless flame, which gave but little light, was obtained. Now the object of the small hole which

you see under this burner (which is a form of Bunsen burner) is to allow the air to enter and mix with the gas before it is ignited."

"We use Bunsen burners in the laboratory at the Technical School," said Arthur; "only ours are a different pattern to the one you have. In the lesson we had upon it, the teacher showed, with the aid of a white porcelain dish, the great difference between the flame obtained by burning gas alone and that of the Bunsen burner. When he held the dish in the ordinary gas flame, it became instantly covered with soot; but a similar dish held in the Bunsen flame remained perfectly clean."



Bunsen Burner for use in the Laboratory.

"Quite right," said the doctor; "that explains why gas fires are so exceptionally clean; but they require good ventilation if the products of combustion are not to escape into the room.

"In one form of gas-fire the open grate is filled with pieces of *asbestos* which are made red-hot by means of several burners placed under the grate. By such an arrangement the cheerfulness of the open coal-fire is partly secured.

"Before leaving the question of gas as a means of warming, I must not forget to mention that many gas-stoves are now made which warm the air before it is admitted into the room. In structure they are somewhat like the ventilating

stove of which I spoke before, except that the heating power is gas instead of coal."

WARMING BY HOT WATER.

The next conversation which the doctor had with the boys was devoted to the best means of warming very large rooms, schools, and public buildings of all kinds. For such places the open fires especially cannot be depended upon, and it is found better to warm them by means of pipes carrying hot water.

To make this part of his subject quite clear, the doctor began by asking his nephews "where they would place the kettle if they wished to boil some water quickly."

"Upon the fire, of course, uncle," said Arthur readily.

"But why do you say 'of course'?" asked his uncle.

"Because I think it would never boil if I put it under the grate," said Arthur.

"Let me see if I can help you to understand a little more precisely the reason for putting the kettle over the fire," said their uncle. "Heat has a similar effect upon water to that which it has upon the air; it makes the water expand and become lighter. This fact I can prove in a simple manner. Here I have a couple of glass vessels, of equal weight

and of equal capacity, in a pair of scales, and I now pour a pint of cold water into the one, and a pint of hot water into the other. There is no mistake as to which is the heavier; for you see that the scale-pan with the vessel of cold water sinks down immediately.

Convection Currents.

"Now when the kettle is placed on the fire, the layer of water at the bottom is the first to become heated. In heating, it expands, and, being lighter, at once rises. At the same time, the cooler, heavier water from above sinks downward to take its place. This water is heated, and rises in its turn; and the circulation thus started continues until the water boils.

"To prove this I will show you another experiment. Here are two thin glass tubes; one is closed at one end, but the other is quite open. By means of this cork, through which passes two unequal lengths of narrow glass piping, I can connect the two tubes together. Before making the connection, I must fill the lower tube with coloured water. Then replacing the cork, I fix the upper tube in position and fill it with plain water.

"By means of a spirit-lamp I now heat the lower tube, and you see the warm coloured water commences to rise to top through the one pipe,

while the clear cold water from above sinks to the bottom through the second pipe.

"Now," said the doctor, "if you fully grasp the meaning of the experiment I have just shown you, you will have no difficulty in understanding how buildings can be heated by hot water.

"A boiler, or a large iron vessel filled with water, is placed in the cellar, or somewhere in the lowest part of the building. An iron pipe leads out through the top of the boiler, and passes upwards, being carried through every room until it reaches the furthest end of the building; it then returns and re-enters the boiler at the bottom. Having filled the pipes and boiler with cold water, the fire is lighted. The hot water being lighter than the cold, escapes through the pipe at the top, and, having parted with some of its heat to the various rooms, it flows back again to the boiler. Thus a constant circulation of hot water is kept up in the pipes.

"And that brings me to the end of the talk for to-day."

LIGHTING THE DWELLING.

When the doctor met his pupils again, he had made arrangements to explain to them the various ways by which houses were illuminated. At the outset he spoke of the natural light we received from the sun, and laid great stress upon the fact

that light was almost as important for health as fresh air.

"Sunlight," he said, "does much to keep our homes healthy—a truth which is taught us in the old Italian proverb, 'Where the sunshine never goes the doctor does'. Plants which are reared in dark places are always weak and sickly-looking, and so are our little children who are brought up in the dingy alleys which abound in all large towns.

"Light should be everywhere. A dark corner means a dirty corner. Where the light does not penetrate, there, as a rule, the air does not circulate. Dark houses are consequently generally full of dust and dirt, and the rooms smell close and stuffy. The evil effects of a dirty house very soon show themselves in the weakened health of the children, who, like tender plants, are very sensitive to bad surroundings. Let me ask you to remember that *darkness*, *dirt*, and *death* all begin with the same letter, and are closely linked together.

"The people of uncivilized or savage nations rise with the sun and retire to rest soon after it has set. We, on the other hand, continue our work or amusements long after it has gone down; and to enable us to do so we must have artificial light of some kind.

"At the present day this is either obtained by burning candles, oil, or gas, or by electricity. With the exception of the last-named, we must remember

that gas and candle lights give off impurities to the air—a fact which we ought not to forget when arranging for the ventilation of our houses. They, indeed, have the same effect upon the atmosphere as the breathing of human beings: they consume the oxygen and replace it by carbonic acid gas.

"It has been calculated that one candle consumes as much oxygen as one man; and an ordinary gas-burner, consuming three cubic feet of gas per hour, will make the air as impure as three men would do in the same time.

"This reminds me of a story told of a man who took an interest in natural and practical science. His wife was a timid woman, and terribly afraid of robbers. When he first learnt about a gas-jet having the same effect upon the air as the three men he told his wife, and tried to urge upon her the necessity of turning down the gas when not required, not only for the sake of saving, but in order to keep the air pure and wholesome.

"His wife, however, did not give much heed to his advice, and one day when he returned home and found the gas full on in the kitchen he said to her, 'Why do you keep three men in the kitchen? What are they there for?' 'Three men, John!' she exclaimed. 'They must be robbers.'

"'And so they are,' said her husband; 'they are robbing us of the very air we require as well as of our pence.' His wife, though considerably frightened,

then remembered what she had been told, and went at once to turn down the gas-jet.

"Before the introduction of oil and gas, rush-lights and candles were the only means the people had of lighting their rooms. They only gave a very feeble light, and smelled badly, and the wicks required snuffing from time to time. The old-

Old Candle Snuffers and Tray.

fashioned snuffers and tray are still kept by some as a curiosity of the days gone by.

"The mineral oils, such as petroleum and paraffin, are so much cheaper than candles that the latter are now little used except sometimes for lighting bed-rooms. But the superiority of petroleum and paraffin over candles is to be found in their greater illuminating power. The brightness of a flame depends upon the amount of carbon which is supplied to it. Thus on account of insufficient carbon, the flame of a spirit-lamp is only slightly luminous; but if to the spirits of wine we add a little turpentine—a liquid rich in carbon—you see the flame becomes brighter immediately. Now both petroleum and paraffin are also very rich

in carbon, and it is for this reason that they give such a brilliant light when properly burnt.

"Many persons object to lamps because accidents have occurred from their use; but the same argument may be used against gas or any other form of lighting. It is generally found when accidents have occurred that they have arisen simply from carelessness. Either an attempt has been made to fill the lamps whilst in use, and the oil has caught fire; or by blowing down the chimney to put out the light the oil in the holder has been kindled; or a common oil which readily explodes has been used.

"It is a good plan to test the quality of the oil before putting it into the lamp. This can be done by first mixing a cupful of boiling-water with an equal quantity of cold water and then pouring upon it a tea-spoonful of the oil. If the oil takes fire when a lighted match is held near it, it is quite unsafe for use.

"All the best kinds of lamps are now fitted with a patent extinguisher. By pressing down the lever-handle at the side of the burner a metal sheath is closed over the burning wick and puts it out."

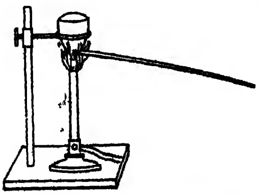
SOME MORE LIGHT.

"The employment of coal-gas for lighting may be said to date from the year 1792, when a Scotsman,

named William Murdoch, then residing at Redruth in Cornwall, lighted his house and office with coal-gas made in an apparatus of his own construction.

"But it was not until the year 1798 that gas really began to take the place of the old-fashioned oil lamps and candles, and even then it did so only to a very small extent. In 1809 a gas company was formed in London for the purpose of lighting the town with gas. At first all kinds of objections were raised to the scheme; and four years elapsed before the persons in power, and the people generally, looked with favour upon it. From that time up to the present the history of gas-lighting has been one of steady progress, and its only great rival now is the electric light.

"A very simple and well-known experiment will give you an idea of the way the coal-gas is made. Into the bowl of a common clay pipe I put a few bits of coal about the size of a pea, and then cover them with a plug of clay in order to shut out the air. I now make the bowl of the pipe red-hot in this gas-flame or, as you may do, in the fire. Smoke at first issues from the stem of the pipe, but if a light be held near, in a few seconds the gas will take fire and will burn with a yellow flame.



Coal Gas manufactured in a Pipe-bowl.

"In gas-works, instead of tobacco-pipes, fire-clay

retorts are employed, in which several hundredweights of coal are heated at a time. In from four to six hours all the gaseous matters of the coal have been driven off, leaving in the retorts nothing but 'coke'.

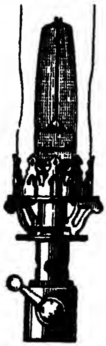
"The gas which is obtained in this way is very impure, and before it is sent along the pipes to the houses and shops it goes through several processes to make it as pure as possible.

"In all houses where coal-gas is used as a means of illumination, steps should be taken to secure proper ventilation and so to get rid of the impurities; otherwise the air of the rooms will soon become loaded with carbonic acid gas and water-vapour.

"If at any time you should notice a smell of gas in your rooms, be sure not to take a lighted candle with you in seeking the place where the gas is escaping. A mixture of coal-gas and air is very explosive, and if you carry a light into a room full of such a mixture there is danger of a violent explosion. Whenever a strong smell shows that there has been an escape of gas, your first duty is to turn off the tap at the meter, and to open the doors and windows to let the gas out. A gasfitter should then be called in to put matters right again. Until he comes the leak can be stopped up with soap.

"Recently a great improvement has been made

in gas-lighting by the introduction of the 'incandescent gas-light'. By using a Bunsen burner we ensure a more perfect combustion of the gas, but since the flame of the Bunsen burner is non-luminous, it is consequently useless for lighting purposes. Now, if the flame be surrounded with a mantle of asbestos which has been treated with the sulphate of zirconium, it in a few moments heats the mantle to white heat, and a brilliant light is obtained; much more brilliant than the ordinary gas-flame and with a far less consumption of gas. Both flame and mantle must be inclosed in a glass, or 'steatite' chimney.

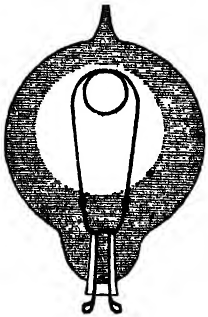

The Incandescent Gas-light.

"Passing to the last mode of lighting, the electric light is, without a doubt, the very best from a health point of view. It does not make the air impure, nor the rooms hot, like gas and oil-lamps; and the chief reason for its not being more commonly used is its great cost.

"The electric lamps at present in use are of two kinds—the *arc lamp* and the *incandescent lamp*. In the former we have two carbon sticks, or candles as they are called, placed point to point, and inclosed in a glass globe filled with air. A very powerful current of electricity is sent through these points, which heats them to an intense whiteness, and so causes a brilliant light.

"The incandescent electric lamp consists of a loop of carbon wire fixed in a glass globe from which all the air has been taken out. The ends of the wire are joined to a machine which produces the electri-

Arc Light.



Incandescent Lamp.

city; and as the current flows along, the loop becomes white-hot, and produces a brilliant light."

DRAINAGE OF HOUSES.

Before the time arrived for another conversation, a question of the greatest importance to the town in which the Cottrells lived had been discussed and settled. At the meeting of the Town Council on the previous day, it had been decided to spend a

large sum of money upon a new sewerage scheme, and that the work was to be proceeded with at once.

The town had grown rapidly of late, and it was a wonder to the inhabitants that the matter had not been taken in hand before.

So when his pupils came on the following Saturday, the doctor decided to speak about the drainage of houses.

"Where a house should be situated," he said, "and of what materials it should be made are matters of much importance; but I think the question of how it should be drained is of still greater importance. Typhoid fever, diarrhœa, sore-throat, and diphtheria are always lurking about in those districts which are badly drained.

"Of course, I know the removal of sewage is always a difficult problem in towns; but it is one that cannot be neglected, if we bear in mind how much the health of the people depends upon good drainage. Already I hear that the Council has taken more land at the Sewage Farm in order to better dispose of the sewage of the town.

"It is a pity in one sense that ours is not a sea-side town; the sewers could then be carried for a distance into the sea and the sewage quickly got rid of.

"In a good system of house drainage the sewage of each house is rapidly carried away by the house-

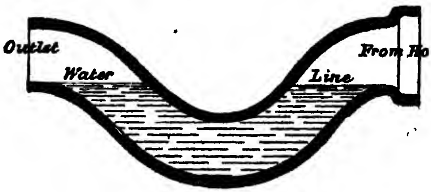
drains and passed into the common sewers. Unfortunately, many house-drains are a great source of danger to the health of those using them, and therefore their proper construction demands our first attention. In the first place before a pipe is laid, the trench in which it is to lie should be dug out from end to end, and the bottom levelled to the proper fall throughout. Then, as the pipes are laid down, a hollow space should be cut out under the sockets at the junction of the different lengths of pipe, so that the body of each pipe may rest upon a firm foundation. By doing this the chance of a pipe breaking under the weight of soil upon it when the trench is filled in is greatly diminished.

"In the next place, drains are not always properly jointed. There is a great temptation to do such work badly, because it is hidden from view. I have known men, in order to get through their work quickly, simply insert the plain or spigot end of one pipe into the socket of the next, without using any joining-material at all.

"Every junction should be made perfectly water-tight by means of good cement, care being taken to clear the joints of cement projecting at the inside. The very best way of proving the soundness of a drain is to plug it at one end and fill it with water; a faulty joint will be speedily discovered by the water oozing out. Unless the joints are quite water-tight, the sewage will soak through into

the surrounding soil, and serious injury to health will probably follow.

"Another source of danger arises from not having the drains properly *trapped*, as it is called. The gas in the sewers and drains, known as *sewer-gas*, is so dangerous to health that it must on no account be allowed to enter our houses. In order, therefore,



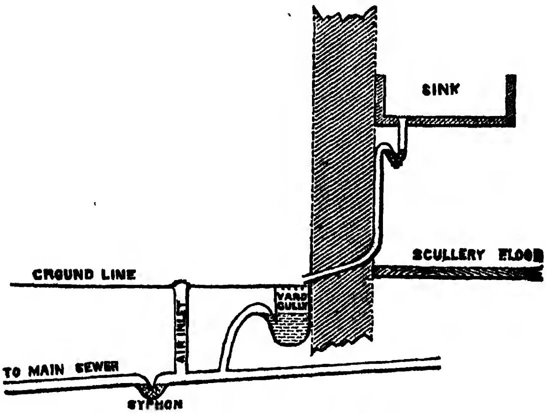
Syphon Trap.

to keep it out, drain-traps of various kinds are used. Some of these are good, others very bad. One of the best and simplest is the syphon trap. It is merely a bend in the pipe, which remains filled with water. As air does not pass through water unless great pressure is put upon it, the sewer-gas in the drain is kept back by this barrier of water. One trap should be placed between the pipe leading from the inside of the house to the drain, and another between the drain and the sewer.

"All waste-water pipes, such as sink-pipes, bath-room pipes, and rain-water spouts, should end in the open air over a gully or trap. There will then be a clear space between them and the drain; and if, by any possible chance, sewer-gas should find a way

out of the gully, it would escape into the outer air, instead of passing up those pipes into the rooms with which they are connected.

"If the drains are constructed in the manner I



Arrangement of Waste-pipe from Scullery Sink.

have told you there is little to fear, and they will not easily go out of order unless the householders themselves are very careless. That, unfortunately, is too often the case. Only the other day my attention was drawn to a house where the drain was clogged. When the drain was opened it was found that the stoppage was due to a house-cloth which had got into the drain. Tea-leaves and human hair are often thrown down the drains, and nothing is more likely to choke them. Drains sometimes become clogged with fat from kitchen slops.

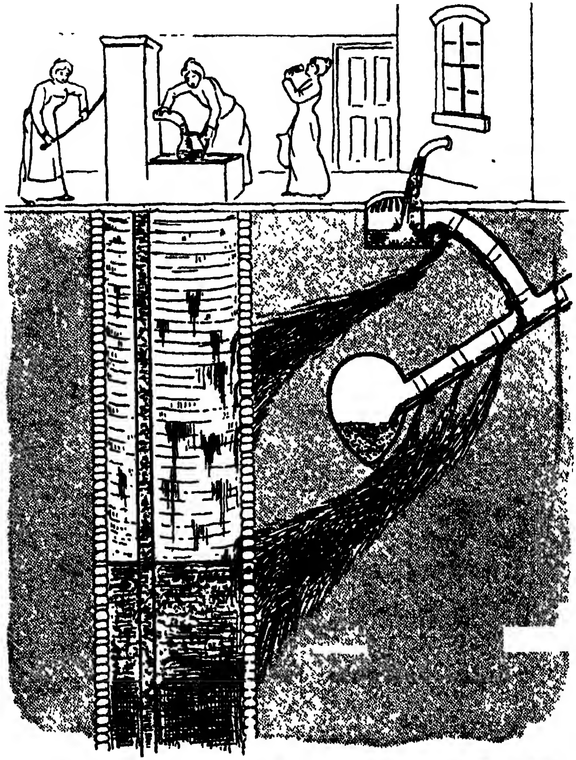
To prevent this a bucketful of hot water with a handful of soda dissolved in it should be poured down once or twice a week."

THE DANGERS OF DEFECTIVE DRAINAGE.

"In our last talk," said the doctor, "I explained to you how the house-drains should be constructed, and briefly hinted at the dangers arising from defective drainage. The history of the past is crowded with examples of the ravages of typhoid fever and cholera, and even now cases are occurring almost daily, which clearly prove that these diseases are caused by defective drainage.

"Either from bad workmanship, or from the subsidence of the soil after they are laid down, the drains are frequently not water-tight. The sewage, therefore, instead of being washed at once into the main sewer, escapes at every joint, and percolates into the soil. Should there happen to be, near the drain, a well from which people draw their supply of drinking water, some of the filth will most surely gain an entrance into it, and so contaminate the water. The very thought of drinking such water is disgusting in itself, but, when it is remembered that the germs of the two diseases I have already named are found in sewage, you will see for yourselves the terrible consequences which people are

exposed to where such a shocking state of affairs exists.



How People Drink Sewage: Drain Leaking into a Well. (By permission, from a diagram in "Dangers to Health", by E. P. Teale.)

"Now perhaps you would expect that the water so contaminated would in appearance be different from pure water, and that the people who drink it

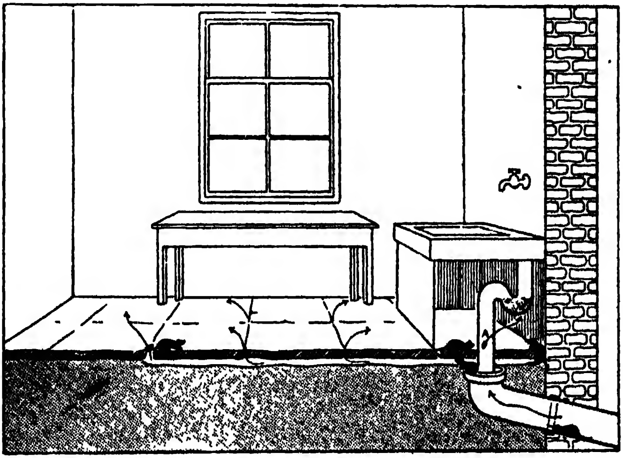
must do so with their eyes shut. That, however, is not the case; for it frequently happens that water polluted with sewage is clearer and more sparkling than water which is perfectly pure.

"A case of this kind comes vividly to my mind. It is known as the 'Broad Street Pump Outbreak', on account of the violent outbreak of cholera in the parish of St. James, Westminster, where the well was situated. In the course of five or six days from the 31st August, 1854, no less than 500 persons died of this disease within a radius of not more than 200 yards. On inquiring into the cause of the epidemic, it was found that the pump-well was connected with a neighbouring cess-pool, and nearly all those who had died had drunk of this water, which was noted for its freshness and sweetness.

"In connection with this case one very remarkable instance was noted. A lady who was living at Hampstead, about three miles away, had heard about this bright, sparkling water, and she accordingly sent a bottle to be filled with it. Both she and her niece drank the water, and both died of cholera, though no one else in the neighbourhood of her house suffered from the disease.

"The appearance of rats in a cellar, or under any ground-floor room may be taken as a sign that either a drain is broken or untrapped. If rats can escape from a drain into the house, it is evident

that sewer-gas can do the same. Moreover, these creatures may be the means of carrying in their furry coats the germs of disease from one house to another. Such a warning as these unwelcome visitors give should be immediately attended to.



Rats and the Tale they Tell.

A, Hole gnawed by rats in drain-pipe. The arrows show the cracks and crevices through which sewage-gas finds entrance. (After a diagram in "Dangers to Health", by E. P. Teale.)

"Instances have occurred where the leakage from drains has gone on to such an extent and for so long a time that cess-pools have been formed by the escaping sewage, and these have remained quite unsuspected until a serious illness has broken out. In this way cess-pools are sometimes formed under the house, a state of things which actually caused the death by typhoid fever of the Prince Consort.

After his death a cess-pool was found under the prince's study, just beneath the spot where he was accustomed to sit.

"There have been cases in which the water-supply of towns is drawn from a river into which the sewage is poured. This was the case for many years in Glasgow. When the cholera visited this city in 1832, and again in 1854, the inhabitants were drinking the impure water of the river Clyde, and the result was that nearly 3000 people died in the one year, and close upon 4000 in the other. As the drinking-water was suspected to be the cause of the high death-rate, it was resolved to obtain a fresh supply from Loch Katrine, which in course of time was done. Now note the result. When the next outbreak occurred, in 1866, the number of deaths from cholera was only 68.

"Typhoid fever has a similar history. I will give but one example. In the autumn of 1867 a severe outbreak of this disease occurred in the village of Terling, in Essex. Of its 900 inhabitants about one-third were attacked, and 41 died. The village consisted chiefly of labourers' cottages, and stood upon the gently-sloping banks of a small stream called the Ter. Filth of every description surrounded the cottages, and the drainage found its way into the wells, or into the stream from which the inhabitants took their drinking water. I have already told you the result; typhoid fever broke out

with terrific violence, and about one-third of the villagers were stricken down with this horrible disease.

"I could give you many other examples besides these; but I think I have said sufficient to show you the dangers of defective drainage."

WATER-SUPPLIES.

The "water-supply" of houses was the next subject to engage the attention of the doctor and his two nephews.

"Water," said the doctor, "is a prime necessity of life. It is required for drinking, for the cooking of food, for personal washing, for cleansing cooking utensils, clothes, and houses, for the removal of sewage and the flushing of drains, and for many other purposes besides.

"In our houses we get water so easily, by simply turning on the tap, that we are apt to forget the trouble and expense which are incurred in supplying a large town with an abundance of pure water.

"Our supply here is obtained from a reservoir which lies in the high ground a few miles out of the town. It was formed by building a strong stone wall or dam across the head of a valley; and into the huge basin thus made several streams pour an excellent water for domestic purposes. From the

reservoir the water is brought to the town by large iron pipes or *mains*, which send off smaller branches into the streets, and from these the water is carried into the houses by smaller leaden pipes ending in taps.

"Many other large towns are supplied in a similar manner. Thus Liverpool draws its water from a large reservoir constructed in the heart of Wales, and Birmingham is following the example. Glasgow is supplied from Loch Katrine, the lake which Sir Walter Scott describes in his poem, 'The Lady of the Lake'. Manchester gets its water from Lake Thirlmere in the Lake District; and so on.

"The object of constructing the reservoirs on high ground is to avoid the necessity for expensive machinery which would be otherwise required to send the water to the houses. Water always rises to its own level; so that if a reservoir is at a higher level than the houses to be supplied, there will be no difficulty in getting the water, even in the top rooms of the highest buildings.

"Before our reservoir was made the inhabitants had to depend chiefly upon pump-wells. Fortunately the water was of good quality, and not contaminated with sewage, as in the examples I gave you last week. But these shallow wells, as they are called, unless they are exceptionally well made, must always be viewed with a certain amount

of suspicion. It is such an easy matter for the drainage from the soil around to get into them, and pollute the water. Deep wells, like those known as *artesian* wells, are free from such impurities; and even in London the artesian wells, some of

Section of Hillside.

A, The upper part of the hill—limestone—through which the rain-water passes. B, The clay below, through which the water cannot pass, and upon which it flows to, C, The spring, or place where the water breaks forth from the hill.

which reach a depth of 1100 feet, yield a wholesome drinking water.

"In country places the water of springs is largely used. As a rule it is very hard, but generally excellent drinking water. The chief drawback, however, to the springs lies in the fact that many of them cease running during the summer, because they are dependent upon the rainfall.

"Of all the liquids we know, there is not another that will dissolve so many different substances as water. Even some of the rocks which appear to

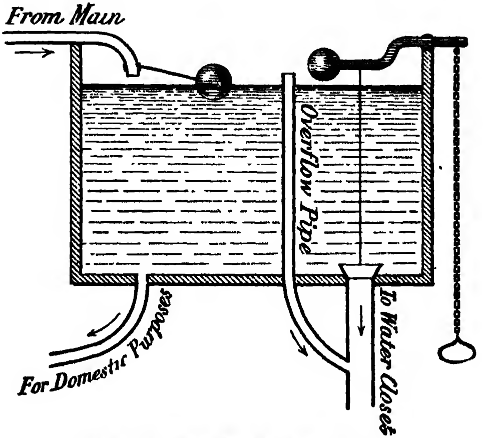
be very compact can be readily dissolved by it. Water, therefore, which has flowed over the surface of the ground, or soaked through the rocks, will certainly contain some amount of mineral matter in solution. Such water is said to be *hard*, because it is difficult to make a soap-lather with it. Rain-water, on the other hand, is free from mineral matter, and is known as *soft* water. For washing purposes it is much better than hard water.

"As in many other towns, our supply of water is not *constant*; that is, to prevent waste, the water is only turned on in the mains for a few hours each day. It is therefore necessary to have cisterns in order to store sufficient water for use during the time when the water is turned off. Now, cisterns in houses are apt to be a means of rendering the water impure, and great care should be taken to have them made of the proper material. The best material for cisterns is slate, because it is not corroded by water, and consequently the water receives no impurity from it.

"All cisterns should be carefully covered over by a well-fitting lid to keep out the dust and dirt, and should be in such a position that anyone can easily get at them for cleaning purposes if necessary.

"Occasionally the tap which fills the cistern gets out of order, and then the water keeps running in; so that in time the cistern overflows. To prevent this, an overflow pipe is fixed in the upper

part of the cistern, to carry the excess of water away. This pipe must always be taken through the house wall, and made to end over a gully. On no



Section of a Cistern from a House in London.

account must it be carried into the drain; for then the foul gases will ascend from the drain and be absorbed by the water in the cistern. The drawing I have here represents the section of a cistern taken from a house in London. A worse arrangement it is impossible to conceive."

THE LAST OF THE TALKS.

"Water for drinking should be perfectly clear and colourless; and should contain some dissolved air, or be *aerated*, as it is called. I expect you

know how 'flat' and insipid boiled water tastes, and this is because the heat has driven the dissolved air from the water. In the next place, it should have no taste, and no smell, even though it may be kept for some time. A bad odour shows that there is some kind of decaying matter in the water, which may prove dangerous to those who use it. Lastly, the water should not be too hard; for the presence of too much mineral matter in water is supposed to be the cause of certain complaints in the body.

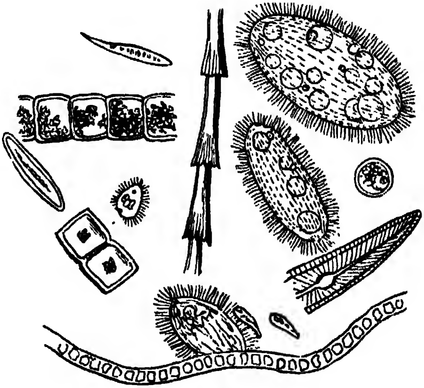
"Since water is such a great solvent, you will not be surprised when I tell you that it is never found perfectly pure in nature. There is always some kind of matter or other dissolved in it, a fact which is proved by the presence of *fur* in the tea-kettles. Now whatever the nature of these materials may be, we speak of them as *impurities*, though many of them may be harmless enough.

"The dissolved impurities are, as a rule, invisible; but you can prove that they are there just as easily as you can the presence of the sugar in your tea. Sometimes, however, when you hold up a glass of water to the light, you may see very short pieces of hair, fibres of wool, and many other tiny specks floating about in the water. These we call the suspended impurities.

"But whether the impurities are dissolved in the water or only suspended, they belong to one of the

two great classes of matter—*Organic* or *Inorganic.* Organic bodies are those which belong to the animal or vegetable world; the inorganic ones are of the mineral kingdom. Of the two classes we dread the organic impurities far more than we do the others; and for a reason I pointed out in the last talk.

"The commonest inorganic impurity is the one known as *bicarbonate of lime*; and it is from this substance that the fur of the kettle is formed when the water is boiled.



Some Animal and Vegetable Structures found in a Drop of Thames Water.

This explains why water becomes softer on boiling; the lime, as it is shortly called, is made to leave the water and settle as a lining of *fur* in the tea-kettles. But as this increases the thickness of the sides of the kettle, and since, moreover, *fur* is a very bad conductor of heat, it is clear that the water must take longer to boil; and so many people make a practice of putting a marble or a small oyster-shell into their kettles, the idea being to make the *fur* form upon them instead.

"The presence or absence of organic impurities in

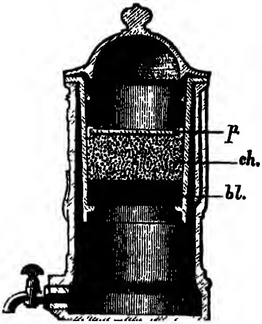
water can be readily discovered by a very simple test. Take a tall, clear glass vessel, and nearly fill it with pure or distilled water. Now add sufficient Condy's fluid, which may be procured from any chemist, to tinge it slightly pink. Then do exactly the same to the water you suspect, and compare the colours of the two samples a few hours later. If the pink colour in the suspected water does not disappear, or is not changed in the least, you may conclude that the water is safe to use. If the colour changes to yellow, organic matter is probably present to a considerable amount, and consequently the water is totally unfit to drink.

"If we are doubtful whether the water we drink be pure or not, our best plan, so as to be on the safe side, is to first boil it thoroughly and then filter it. The boiling will not only get rid of much of the hardness which may be present, but will also render the organic matter harmless. The filtering will remove all floating particles, and will enable the water to regain some of the dissolved air which was expelled by the boiling.

"It is a custom with many persons never to drink water before it has passed through some kind o. domestic filter; but my advice to you is not to use filters at all unless they are really necessary. Experience has shown that too much faith is placed upon their purifying action; and I have known cases in which the water after filtering has been even

worse than it was before. This happens frequently in those filters in which the water has to pass through a piece of sponge, one of the worst materials that can be used for such a purpose.

"Probably the best substance to use for filtering is animal charcoal, either by itself or in combination with lime, as in the well-known 'Filtre Rapide'. But whatever material is employed in the construction of filters, it should be frequently taken out and thoroughly cleansed by boiling in water to which some Condy's fluid has been added, and afterwards rinsing it well in water before putting it back in the filter. When purchasing a filter always satisfy yourself that it can be easily pulled to pieces and as easily put together again. Unless this can be done it is not worth having, and is sure to become a source of impurity to the water.



Cleansible Filter.

bl., a block of carbon; *ch.*, a layer of granulated charcoal; *p.*, a porous earthenware plate to keep the powdered charcoal in its place.

"I have now discussed with you the principal topics connected with the preservation of health, and it is left to you to carry out the instructions I have laid down. I can only repeat what I have pointed out all along, and that is the necessity of paying great attention to the sanitary arrange-

ments of our homes. Thousands of people die annually from diseases which are known to be preventible. To do what we can by proper care to get rid of such diseases altogether is a duty which we owe to our neighbours no less than to ourselves. In the words of St. Paul: 'We are members one of another . . . and whether one member suffer, all the members suffer with it, or one member be honoured, all the members rejoice with it'.

"If everyone would only faithfully carry out the lessons I have attempted to teach you, healthy homes, instead of being the exception, would then become the rule."

SUMMARY.

THE PHYSIOLOGY CLASS.

Human Physiology is the science which treats of the healthy life of man's body. It teaches us how the various parts of our own bodies act during health, and what use their work is to the whole man:

The science which treats of the structure of the body is called Anatomy. These two branches of knowledge are therefore very closely related.

Microscopes are instruments which enable us to see objects which would be invisible to the unaided eye, or which increase the seeming size of objects. They are of two kinds—simple and compound. A simple microscope has only one double-convex lens; a compound microscope has two or more, fitted one above the other in a brass tube.

THE SKELETON.

LESSONS: THE FRAMEWORK OF THE HOUSE I LIVE IN; MORE ABOUT THE FRAMEWORK · THE FRAMEWORK PULLED TO PIECES.

Skeleton.—The body is built up on a foundation of firm, hard bones, which, taken together, are called the Skeleton.

Uses of the Skeleton.—(*a*) It gives a shape to the body. (*b*) It gives firmness to the body. (*c*) It serves to protect the soft organs within us. (*d*) It enables us to move.

Joints.—The places where any two bones are fastened on one another are called **joints or articulations.**

They are either **movable** or **immovable.** The bones of the head have immovable joints. The movable joints are either **perfect** or **imperfect.** Imperfect joints are those in which the two bones are fastened together with cartilage or gristle. The spine gives the best example of imperfect joints. Perfect joints are those which allow the bones to slide upon one another easily, such as at the elbow, shoulder, knee, hip, &c. In all perfect joints we find: (1) smooth gristle covering the ends of the bones; (2) a lubricating fluid; and (3) ligaments to keep the bones in place.

For general description the body may be conveniently divided into Head, Trunk, and Extremities.

Skull.—The head consists of the **cranium** and the **face.** The framework of it, called the **skull,** is made up of 22 bones—8 belong-

ing to the cranium and 14 to the face. The bones of the cranium, though spoken of as 8 separate bones, are in adult life one continuous mass of bone; for they fit into each other by saw-like edges, called **sutures.**

These serve to make the brain-pan less liable to fracture; and if fracture does take place they limit its extent. Moreover, they allow of a connection between the circulation within and that without the cranium.

In a child up to an age varying from three to six years there are considerable intervals between these bones, called **fontanelles.** Ignorant nurses, with an idea of making the shape of the head better, often press the bones of the baby's head together. It is a most dangerous practice, and the child may be ruined for life.

Bones of the Trunk.—The trunk is that portion of the body which remains when the head and extremities are removed.

It is divided by a muscular partition, called the diaphragm, into two parts—the **thorax** (or chest) and the **abdomen.**

The **backbone, spine,** or **vertebral column** are three names for that pillar of bones which extends from the neck to the lower extremity of the trunk. In early life it consists of 33 bones, called **vertebræ**; but in adult life the lowest four form one bone, **coccyx**; the five above these also unite into one, called the **sacrum.**

Each vertebra consists of three parts—a body, a ring, and the three processes. The vertebræ are placed over each other, but not in contact, for between each pair of vertebræ is a pad of gristle or cartilage.

The **Ribs** are twelve in number on each side. Each is socketed to the backbone, and bound by such strong ligaments that it is impossible to dislocate a rib.

The first seven ribs are called **true** ribs, and the lower five **false** ribs. The true ribs are jointed directly to the breast-bone by pieces of cartilage; the other five are not so fixed. The 8th, 9th, and 10th pairs are united to the 7th pair; whilst the 11th and 12th pairs are not fixed at all at their front tips, and are known as floating ribs.

The **Pelvis** or basin is formed by the sacrum and the coccyx at the back, and by a large irregularly shaped bone, which comes round to the front. The most prominent part of this bone is known as the hip-bone.

The **Extremities,** or limbs, are the two arms and hands, and the two legs and feet.

In each arm there is one bone from the shoulder to the elbow, and two bones from the elbow to the wrist. In the wrist there are eight small bones, arranged in two rows of four each. In the palm of the hand are five bones, to which are jointed the fingers and thumb. Each finger has three bones, and the thumb has two. The arm and hand together have thirty bones. Each leg consists of a thigh-bone (femur)—the largest bone in the body—and two bones from the knee to the ankle. In the ankle are seven bones, and in the sole of the foot five. Each toe consists of three bones; except the great toe, which has only two. The joint at the knee is covered in front by the patella or knee-cap bone. The leg and foot thus consist of thirty bones in all.

DEFORMITIES.

LESSONS: AS THE TWIG IS BENT THE TREE'S INCLINED; MORE DEFORMITIES; ANOTHER FASHIONABLE DEFORMITY.

A **Deformity** is any irregularity or unevenness in the shape of the body. In those parts of the body covered by dress, such unevenness may develop to a considerable extent before it is noticed. Many causes tend to deform the body, among the chief of which are:—

(*a*) **Carrying heavy weights, especially by one arm only.**—A girl is employed in nursing and carrying a baby. It often happens to be more convenient to carry the infant always on one arm, and the weight being thrown on one side, a bent backbone is the result. The same thing may arise from carrying buckets of coal, pails of milk, &c.

(*b*) **Putting a child to stand upon its legs too soon.**—The bones of a very young child are really nothing but gristle, and are therefore easily bent. As age advances the bone hardens and the curvature of the leg bones becomes permanent.

(*c*) **From a carelessness in sitting or standing.**—The rounded shoulders and backs are brought about in this way. Badly constructed school-desks will also cause a curvature of the spine.

(*d*) **From tight-lacing.**—The effect of tight clothing about the waist is to crush the ribs inwards, and to compress and displace the abdominal organs.

(*e*) **From tight boots and tight gloves.**—The effect of excessive pressure upon the feet is best seen amongst Chinese ladies.

Wearing small gloves also cripples the hands.

STRUCTURE OF THE SKIN.

LESSONS: THE COVERING OF THE HOUSE I LIVE IN; THE GLANDS OF THE SKIN; MORE ABOUT THE GLANDS OF THE SKIN.

What the Skin is.—The skin is an integument or protective covering for the whole of the external surface of the body.

Its Structure.—It consists broadly of two layers: the **dermis** beneath, and the **epidermis** over this. The dermis or true skin contains both blood-vessels and nerves; the epidermis has neither.

Glands of the Skin.—Two kinds of glands are found in the skin—the **sweat glands** and the **sebaceous** or **oil glands**. The sweat-glands are minute tubes about $\frac{1}{4}$ in. long, and $\frac{1}{300}$ in. in diameter. The total number in the body is about two-and-a-half millions. Each gland is seen to consist of a little coil in the dermis, from which a little pipe runs up to the surface of the skin. The

mouth of a gland is called a pore. The function of these sweat-glands is to separate from the blood the perspiration and sweat, which, if left in the body, would be injurious.

Besides the sweat-glands, the skin contains a smaller number of oil-glands, which make from the blood a natural oil, which serves to soften the skin and to moisten the hair. Two oil-glands are attached to each hair; and when the skin is in a healthy state this natural oil ought to be sufficient for the hair.

Functions of the Skin.—The skin has several important uses: (1) It is the organ of touch or feeling, including the sensation of heat and cold; (2) It serves as a protection to the deeper parts; (3) By its means the temperature of the body is regulated; (4) It serves for the excretion from the system of the perspiration, and a small amount of carbonic acid gas; (5) The skin also slightly absorbs fluids. Castaways have been saved from death by thirst, by sea-baths and wearing wet clothes.

THE MUSCLES.

LESSONS: THE DEAD RABBIT; HOW THE MUSCLES WORK.

Muscle.—The bones are everywhere covered by flesh, or, as it is properly called, **muscle.** It is arranged in masses of different shapes and sizes, and forms what are usually known as the muscles.

Structure of Muscle.—A muscle can be separated into fine threads about the one four-hundredth of an inch in diameter. These threads are called **fibres.** Some of them have faint markings upon them, longwise and crosswise; the others have not. Hence the former are known as **striped** fibres, and the latter **unstriped** fibres.

A striped fibre can be divided either into round discs, or into still finer threads called **fibrillæ.** Thus several fibrillæ make up a fibre. A number of fibres are then bound by a thin skin into a bundle, and several of these small bundles, laid regularly side by side, make a larger bundle. Lastly, several of these larger bundles make up each muscle.

The muscles are usually thick and fleshy in the middle, and thin and fibrous at either end where they grow to the bones. These fibrous parts are known as the leaders or tendons.

Each muscle has the power of contracting—that is, of shortening itself, and at the same time becoming thicker. This shortening and thickening of a muscle can be best seen in the biceps muscle of the arm.

THE HEART AND THE CIRCULATION.

LESSONS: THE RIVER OF LIFE; HOW THE RIVER OF LIFE IS KEPT MOVING; THE JOURNEY OF THE RIVER OF LIFE; A WONDERFUL SIGHT.

If we happen to cut any part of the body, it bleeds. This shows that the blood is coursing all through the body, getting into every nook and corner. The blood is a red liquid thicker than water, because, in addition to the water, it contains a large amount of solid matter.

Constitution of the Blood. — The constitution of the blood has been ascertained by the help of the microscope. If a drop of blood be placed on a thin glass, and another thin piece of glass pressed on it, it can then be seen that the blood consists of a colourless fluid with little reddish bodies floating in it. In a few minutes the particles become fewer and larger, the fact being that they have accumulated in masses. The red bodies are called **corpuscles**, and the fluid, **plasma**. A close examination of the blood will discover a few **white corpuscles** in addition to the red ones.

There are about four or five hundred red corpuscles to every white corpuscle.

Coagulation of the Blood.—If another drop of blood be placed on a piece of glass and allowed to stand, it becomes a red jelly, sticking to the glass. A little later drops of a thin fluid ooze out of it, and a dark red clot, nearly dry, remains. This is the process called coagulation. The process, however, cannot be fully observed without a larger quantity of blood.

HOW THE RIVER OF LIFE IS KEPT MOVING—THE HEART.

The Heart.—The heart is a hollow muscular bag, placed between the lungs in the centre of the chest. Its work is by the successive contraction and expansion of its chambers to drive the blood throughout the body. It is divided from top to bottom by a thick fleshy wall called the **septum**, so that the right and left halves are absolutely distinct.

Each half of the heart is again divided into two chambers, an upper or **auricle**, and a lower or **ventricle**; but the division in this case is not complete. The right auricle communicates with the right ventricle, and the left auricle with the left ventricle, by oval openings which are called **valves**. The valve in the right side of the heart has three flaps of membrane; the one in the left side only two.

Use of the Valves.—When the blood is passing from an auricle to a ventricle the flaps of the valves hang down into the ventricle; but if the blood attempts to pass from a ventricle to an auricle, the valve rises up and closes the opening. Each valve is prevented from being driven through into the auricle by cords of fine but tough substance, growing at one end to the under surface of the flaps and at the other to the inner wall of the ventricle.

THE JOURNEY OF THE RIVER OF LIFE.

Objects of the Circulation.—The circulation of the blood is designed for the following offices: (*a*) To distribute the blood to all the organs of the body for their nourishment and stimulation; (*b*) to distribute the blood to those organs of the body (skin, lungs, and kidneys) which cleanse it from impurities; and (*c*) to send the blood to those organs, namely the stomach and intestines, which contain new nourishment ready to be absorbed into the blood.

Arteries.—An artery is a blood-vessel which carries blood from the heart. They not only convey blood to all parts of the body, but also assist in driving it on.

Veins.—Veins carry the blood back to the heart. They have soft thin walls, and usually run side by side with the arteries.

Capillaries.—Everywhere in the body the arteries break up at last into a network of minute vessels called **capillaries.** In these the blood flows more slowly than in either arteries or veins. They have walls so thin and permeable that the fluid of the blood can easily soak through them into the flesh in which they lie; and in this way the blood nourishes the tissues. On the other hand, matter from the tissues can pass into the blood. The capillaries form a connecting link between the arteries and the veins.

The Circulation of the Blood.—The circulation is maintained by the heart. Commencing, say, in the right auricle, the blood passes through the right valve into the right ventricle. From this chamber the blood is forced up the pulmonary artery to the two lungs, where it is purified, and the blue venous blood changed to the red arterial blood. Leaving the lungs by the four pulmonary veins, the blood returns to the left auricle, from whence it passes into the right ventricle. The contraction of this chamber then drives the blood into the aorta, which, with its branches, carries the blood all over the body. Having done its work, the blood is brought back again by the veins to the right auricle from which it started.

Proofs of the Circulation.—(1) The microscope enables us to see the circulation in certain animal structures, such as the web of a frog's foot and the tail or gills of a tadpole. (2) If the large veins are tied near the heart in a fish, the heart becomes flat; if the arteries are tied instead the heart swells as though it would burst. (3) From a wound in an artery the blood spurts out in jets at the same rate as the heart beats.

A CHAPTER OF ACCIDENTS.

Fainting Fits.—Fainting fits are caused by a slight temporary failure of the heart's action.

This may be brought about (*a*) by tight-lacing; (*b*) sudden shock; (*c*) the sight of blood; (*d*) fright; (*e*) a foul, heated atmosphere.

Symptoms.—The symptoms of the ordinary fainting fit are easily distinguished. The face is pale and the skin cold; even the lips look bloodless. The pulse is very feeble.

What to do.—Carry the patient with the head low into a cool room or into the fresh air, and lay him flat. On no account set the person bolt upright. Loosen the clothing about the neck, and bathe the forehead with cold water. Apply smelling-salts to the nose, and give a little cold water to drink when consciousness returns, but not before.

Death from Heart Disease.—People suffering from a weak heart should lead a quiet life and avoid all causes of excitement. Running to catch a train, climbing hills, running quickly upstairs, are positively dangerous practices for such people.

Bleeding.—Bleeding may generally be stopped by the application of cold and pressure. There are two kinds of bleeding: the one, arterial, in which the blood issues from the wound in jets, and is of a bright red colour; the other, venous, in which the blood is dark purple, and flows from the cut in a continuous stream.

When an artery is severed pressure must be applied at once **between the wound and the heart,** near to the cut. As considerable pressure may be required it is best to use some form of **tourniquet.** A simple one may be made with a handkerchief, a length of rope, or anything that can be knotted. This is then placed in position and firmly tied. By twisting the bandage with the aid of a knife or piece of stick, the knot can be made to press upon the artery and so close it. In venous bleeding the pressure is applied **below** the wound.

HOW THE BLOOD IS PURIFIED.

Respiration.—The organs concerned in respiration are the two lungs, which fill the greater part of the chest. To reach the lungs the air we breathe passes down the windpipe, a large hard tube, which is easily felt in the neck in front of the gullet. Within the chest the windpipe divides into two branches called **bronchi**—one bronchus going to the right lung, and the other to the left lung. Upon entering the lungs each bronchus divides and subdivides, until the last and smallest bronchial tube is only about the $\frac{1}{50}$ in. in diameter. At the end of each of these tiny tubes is an air-cell. There are about six millions of these air-cells in the two lungs.

Changes between the Air and the Blood in the Lungs.—The changes which takes place in the air-cells of the lungs between the blood and the air are: Oxygen passes from the air into the blood, and carbonic acid gas passes from the blood into the air of the cells.

THE AIR WE BREATHE.

LESSONS: THE AIR WE BREATHE; FOUL AIR; DANGERS OF BREATHING IMPURE AIR; MORE EFFECTS OF IMPURE AIR.

Composition of Air.—Ordinary air is a mixture of several gases, of which the two chief are nitrogen and oxygen. There are also variable proportions of carbonic acid gas, watery vapour, and traces of ammonia. If we take 10,000 parts of what is commonly called "fresh air", there will be of—

Nitrogen,	7,900	parts.
Oxygen,	2,096	"
Carbonic acid gas,	4	"
	10,000	

Oxygen.—Oxygen is a colourless, transparent, inodorous, and tasteless gas. It is the most abundant of all the elements in nature. Substances which burn in air burn with much greater brilliancy and rapidity in oxygen.

Nitrogen.—Nitrogen is also a colourless, transparent gas, without smell or taste. It will not burn, neither will it support combustion. Its purpose in the air is to modify the action of the oxygen.

Carbonic Acid Gas.—Carbonic acid gas is a colourless and transparent gas, having no smell, but a **slightly** acid taste. It is a heavy gas, and occurs frequently at the bottom of old wells and in disused coal-pits.

Carbonic Acid Gas in the Air.—The carbonic acid gas in the air is produced by the breathing of all animals, by the decomposition of vegetable and animal bodies, and by combustion.

To show the presence of carbonic acid gas in the air, pour some clear lime-water into a saucer, and leave it exposed to the air for a few hours; a crust of carbonate of lime will be found to have formed on the surface of the lime-water, due to the carbonic acid gas of the air joining with the lime in the water.

The difference between inspired and expired air can be shown by drawing fresh air through some lime-water in a flask, and then sending the breath through some lime-water in a second flask. In the former case the lime-water will remain perfectly clear; but in the latter case it will turn white or milky.

Breathing (respiration) removes oxygen from the air, and adds to it carbonic acid gas and "organic matter". The following table shows the changes which occur:—

	Composition of the Air.	
	Before Respiration.	After Respiration.
Nitrogen,	7,900	7,900
Oxygen,	2,096	1,630
Carbonic acid gas,	4	470
	10,000	10,000

Dangers of Breathing Impure Air.—(*a*) **Air vitiated by breathing.**—The immediate effects of impure air are headache, languor, and lassitude, the first symptoms of which are yawning and listlessness. By constantly breathing such air from day to day bronchitis and consumption are sure to follow.

The spreading of typhus fever is also greatly aided by ill-ventilated and overcrowded living-rooms.

As examples of what foul air can do, there are the cases of the "Black Hole of Calcutta", and the steamship *Londonderry*.

Dumb animals also suffer from breathing a foul atmosphere. Each time the cattle plague has visited these shores, the animals attacked were chiefly those that were kept in filthy and badly-ventilated sheds.

(*b*) **Suspended Impurities.**—Diseases of the respiratory organs, such as asthma, bronchitis, and consumption, are caused by the inhalation of dust.

(*c*) **Gaseous Impurities.**—Lung diseases may be produced, and are always greatly aggravated, by breathing the gaseous products from the combustion of ordinary coal. Sewer-air causes vomiting, diarrhœa, and even diphtheria. Carbonic oxide is a great poison, even when breathed in small quantities.

FOOD.

LESSONS: WHY WE EAT; WHAT SHALL WE EAT? A MIXED DIET.

Necessity for Food.—We require food for the following purposes:—

(1) To supply material for building up the body.
(2) To supply material for the repair of the body.
(3) For the maintenance of the bodily heat.
(4) For the production of energy.

Classification of Foods.

The classification of foods depends on the stand-point from which they are viewed. Thus they may be classified according to their source—(1) Animal, (2) Vegetable, (3) Mineral. Or to their state, as (1) Solid, (2) Liquid, and (3) Gaseous.

Or, as is usually the case, according to their composition, as (1) Nitrogenous Foods, or those which contain nitrogen; (2) Carbonaceous Foods, the chief element of which is carbon; and, (3) Mineral Foods, including water, salt, &c. By the last method the foods would be tabulated as follows:—

Nitrogenous or Flesh-formers.	Eggs, meat, milk. Peas, beans, lentils. Bread, cheese, oatmeal.
Carbonaceous or Heat-givers.	Fatty foods, such as butter, lard, dripping, &c. Starchy foods, as rice, arrowroot, sago, potatoes, corn-flour, & tapioca. Sugary foods, as sugar, honey, treacle, &c.
Mineral.	Water, common salt, salts of lime. Salts of potash, sulphur (in eggs).

Necessity for a Mixed Diet.—Since no single class of food can fulfil all the requirements of the body, it will be seen at once that nitrogenous, carbonaceous, and mineral foods must be included in each day's meal. The necessity for a mixed diet is also shown by our longing for a variety of food; not in the sense of a great number of dishes at one and the same meal, but a periodical change from day to day, either in the principal articles of food, or in the manner which they are prepared.

The character of the teeth, some of which are fitted for crushing vegetable foods, and others for tearing and grinding flesh, and the length of the intestines, which are intermediate between those of

purely flesh-feeding (carnivorous) and vegetable-feeding (herbivorous) animals, point to the same truth.

Bread is an excellent food, but if we attempted to live on it alone we should have to eat 4 lbs. of it daily to supply us with all the nitrogenous material required for repairing the waste. In this amount of bread there would be twice as much carbonaceous material as we require; so that half of this carbonaceous matter would be wasted. Take meat again. To obtain all the necessary nitrogen 1½ lbs. would be sufficient; but 4½ lbs. would be required to give the proper amount of carbonaceous food. In this case there would be a waste of nitrogenous food. But by 2 lbs. of bread and ¾ lb. of meat, the requirements of the body will be satisfied.

THE DIGESTION OF FOOD.

LESSONS: THE DIGESTION OF FOOD; SWALLOWING; MORE ABOUT DIGESTION.

Objects of Digestion.—Digestion makes the food fit to enter the blood and nourish the body. The organs of digestion form, or are connected with, a long tube called the alimentary canal.

The Mouth.—The mouth is the commencement of the alimentary canal. In this organ the food is masticated by the teeth, and mixed with the saliva.

Teeth.—During life we have two sets of natural teeth. The first set or **milk teeth** are 20 in number, and the second set or **permanent** teeth are 32 in number, viz., 4 central **incisors**, 2 **canine** or pointed teeth, 4 **bicuspid** teeth, and 6 **molars** or grinders, in each jaw.

Insalivation.—Whilst the food is being chewed there is poured upon it a thin fluid called **saliva**, which is secreted by six salivary glands. The active principle of the saliva is a peculiar substance called ptyalin, which has the power of converting starch into grape-sugar. This explains why starchy foods when kept in the mouth for a time increase in sweetness.

Swallowing.—As soon as the food has been thoroughly masticated and mixed with saliva, it is next swallowed. At the moment of swallowing two other things happen—the **uvula** rises up to close the passage leading to the nose, and the epiglottis shuts down over the windpipe to prevent the food going in that direction. Once the food is in the gullet or food-pipe, it is gradually pushed onwards by the contraction of muscular fibres of the gullet, into the second organ of digestion, the stomach.

The Stomach.

The stomach lies principally on the left side of the body, beneath the diaphragm and a part of the liver. Its walls consist of several layers, the chief of which is the inner lining or **mucous membrane**, because it contains the glands which secrete the gastric juice.

When the food enters the stomach it is not allowed to remain still, but is rolled round and round, and at the same time is mixed with the gastric juice. The effect of this is to change the food into a thin grayish-coloured fluid called **chyme**. The gastric juice has no action on starch or on fats; it only digests the nitrogenous materials.

Small Intestine.—From the stomach the food passes into the small intestine, where two other digestive fluids are poured upon it. The **bile** from the liver breaks up the fatty portions of the food, and the **pancreatic juice** from the pancreas converts any remaining starch into sugar.

The digested food in the intestine is thicker and whiter than chyme. and is known as **chyle**.

Absorption of Digested Food.—The food which is completely digested in the stomach is absorbed by its blood-vessels; but most of the digested food is taken up by the villi in the intestines.

INDIGESTION.

What it Is.—Indigestion is a disorder arising from the improper working of the various digestive organs.

Causes.—(*a*) **Improper** food, such as unsound or indigestible substances.

(*b*) **Badly cooked** food, such as meat too much over-done.

(*c*) **Drinking cold water** immediately before and during a meal.

(*d*) **Too hot** food.

(*e*) **Too cold** food.

(*f*) **Gluttony**; either from eating too frequently, or taking too much at a time.

(*g*) **Imperfect mastication**, as when food is bolted, or from lack of good teeth.

(*h*) **Impaired secretions** of gastric juice, bile, &c.

(*k*) Too long **abstinence** from food.

(*l*) **Intense study** or **exercise** immediately after meals.

THE NERVOUS SYSTEM.

LESSONS: HOW MESSAGES ARE SENT THROUGH THE BODY; THE NERVOUS SYSTEM; HOW TO KEEP THE BRAIN HEALTHY.

The Nervous System.—The nervous system consists of two distinct systems: (1) the **brain, spinal cord,** and the **nerves,** which together are called the **cerebro-spinal** system; and (2) the **sympathetic nervous system,** connected chiefly with the organs of digestion, circulation, and respiration.

The Brain.—This most important organ consists of three principal parts:—

(1) The Cerebrum or Brain Proper.
(2) The Cerebellum or Lesser Brain.
(3) The Medulla Oblongata.

The **Cerebrum** is nearly seven-eighths of the entire mass, and occupies the whole of the upper part of the skull. It consists of two hemispheres, almost entirely separated from each other by a deep fissure from front to back. Its surface presents a peculiar folded-up appearance, and some of the clefts between the folds are as much as an inch deep. The powers of the intellect, will, and emotions are lodged in the cerebrum.

The **Cerebellum** lies beneath the back part of the cerebrum, and weighs about one-tenth of the entire weight of the brain. Its function, it is believed, is to regulate the muscular movements.

The **Medulla Oblongata** is the thick upper portion of the spinal cord which lies within the skull. It controls the action of the heart and lungs, and is also the seat of sensation.

The **nerves** do not themselves feel; they are only the carriers of messages to and from the spinal cord and brain. Some nerves are coiled round the muscles of the body, and convey to them the commands of the brain, thus causing them to contract. These are called the **motor nerves.** Other nerves carry impressions to the brain; these are the **sensory nerves.** A sensory and a motor nerve generally run side by side.

The **sympathetic system** consists of a set of soft lumps of nerve-matter, which lie on either side of the spine. The lumps, or **ganglia**, as they are called, are connected with each other, and with the spinal nerves, by a network of nerve cords.

Healthy Brains.—For the right and healthy development of the mental powers the brain must be duly nourished and exercised. If unused and inactive the mind becomes dull and feeble. The consequences of imperfect exercise of the brain are the same as in muscles; by want of use it becomes less fit to work, and its power is greatly enfeebled.

On the other hand, overtaxing the brain is equally as injurious. When the eyes are very much used they become bloodshot and defective; we notice this because it is obvious. The same thing goes on in the brain when overtaxed. We do not see this, but we are aware of it by the effect produced—this may be headache, loss of appetite, restlessness, irritability, sleeplessness, and starting or talking in sleep, listlessness, &c.

HEALTHY EXERCISE.

Effects of Healthy Exercise.—(*a*) The size and strength of the muscles are considerably increased.

(*b*) The action of the lungs is increased.

(*c*) The action of the skin is increased.

(*d*) The heart's action is increased in frequency and force, and the circulation quickened.

(*e*) The nervous system is strengthened.

Effects of Excessive Exercise.—Exercise to do good must be regular, and as varied as possible, but never carried to over-fatigue. Excessive exercise produces muscular exhaustion, and the muscles, instead of growing, will commence to waste away. Thus clerks suffer from a complaint known as **scriveners' palsy**, the muscles of the hand being seized with cramp each time writing is attempted.

Effects of Deficient Exercise.—When the muscles are not used they waste away, and become soft and fatty. Their strength is lost, and the least exertion is fatiguing.

Cold feet and chilblains occur chiefly among those who have deficient exercise.

Forms of Exercise.—Walking is the one most generally practised, and perhaps one of the best. Rowing, cricket, football, in moderation, are also useful. In lawn-tennis and swimming all the muscles are made to work; while reading aloud and singing strengthen the voice and lungs.

REST.

Need of Rest.—The exercise of the body must be followed by a period of repose, so that the repair of the tissues may take place.

Rest may be **partial** or **general**. The student who has exercised his brain all day long, will give that organ rest by taking a walk, practising with dumb-bells, and other gymnastic exercises. Thus partial rest is secured by **change of occupation.**

Sleep is the only form of general rest. The amount of sleep required varies with the age. Children require most. For adults, from seven to eight hours are usually sufficient.

Sleeplessness may be due to (*a*) want of exercise; (*b*) overwork, especially too much brain work; (*c*) taking tea or coffee late in the evening; (*d*) retiring to rest immediately after a late meal.

The remedy, of course, is to avoid the causes which produce it. A warm bath, the last thing at night, may also be tried.

CLEANLINESS.

Lesson: HOW TO KEEP THE SKIN CLEAN.

Neglect of the daily bath leads to the accumulation of dirt upon the surface of the body, and the closing of the pores of the sweat and sebaceous glands.

In consequence of this, other organs, principally the lungs and kidneys, are compelled to do extra work in order to get rid of the waste matters; but this they cannot do for long, and so they break down.

Bathing.—To keep the body perfectly sweet and clean, we must have frequent if not daily baths.

Kinds of Baths.—(1) **The Cold Bath.**—A cold bath every morning, followed up by a brisk rubbing with a rough towel, is most invigorating. The best temperature for a cold bath is about 60° F.

(2) **The Warm Bath.**—Cold water does not remove the dirt so efficiently as warm water. Hence a warm bath with a free use of soap should be taken at least once a week. This should be done the last thing at night, because warm water makes the skin very sensitive to changes of temperature, and there is thus a risk of taking a chill from exposure to cold. It also induces sleep.

(3) **The Turkish Bath.**—This is used to bring about a copious sweating by means of hot dry air. The sponging and subsequent rubbing remove all the dead scales of the skin, and the impurities from the glands.

CLOTHING.

LESSONS: WHY WE WEAR CLOTHES; MORE ABOUT CLOTHING.

Use of Clothes.—(1) **To maintain an even temperature** in every part of the body.

(2) **To act as a shield,** protecting the body from the burning rays of the sun.

(3) **To protect the skin** from being torn or injured by rubbing against objects, by accidental falls, &c.

(4) **To keep out the wet,** so that we can withstand exposure to rain and snow.

(5) **As an ornament.**

Requisites of Clothing.—(1) **Clothing must not interfere with perspiration.**—Therefore materials like cotton and linen should not be worn next the skin, as these soon become wetted by the perspiration, and feel cold. Wool, on the other hand, absorbs much moisture, and does not interfere with the evaporation of the perspiration.

(2) **The clothing must not be tight.**—Apart from the injuries which very tight clothing may cause, it is colder than loose clothing. Air is a bad conductor of heat, and those articles of clothing are warmest which have much air in their meshes.

(3) **The weight of the clothing should be properly distributed.**—The clothing should be suspended as far as possible from the shoulders and hips, and not from the waist only. By the latter method there is a considerable danger of compressing the internal organs.

Materials Employed for Clothing.—**Wool** is a bad conductor of heat, and so prevents its escape from the body. At the same time it does not quickly become saturated with perspiration, and for these reasons it should always be worn next the skin in a changeable climate like ours.

Silk is another valuable material for clothing, but its use is limited on account of its costliness. It is a bad conductor of heat,

and for those persons who find wool too irritating for the skin, a thin silk vest is an excellent substitute.

Cotton and **linen** are good conductors of heat, and are soon wetted by the perspiration. They are, however, very durable, and easily washed.

Leather is chiefly used for boots and shoes in this country, and is impervious to moisture.

Colour of Clothing.—As regards the colour of clothing, this is a matter of little importance, unless we are exposed directly to the rays of the sun. In that case the best reflectors, such as white and light gray, are the coolest. Dark colours, like black and navy blue, absorb so much heat that they become exceedingly hot.

THE DANGERS OF ALCOHOL.

Properties of Alcohol.—Alcohol has a burning taste, and an agreeable odour. Strong alcohol, especially **absolute alcohol**, acts as a poison when swallowed; but when diluted, it is, as is well known, stimulating and intoxicating. The beverages which contain alcohol may be arranged as (1) malt liquors, (2) wines, and (3) spirits. Beer contains least alcohol, and spirits most.

Effects of Alcohol.—(1) **On the Stomach.**—Habitual intemperance leads to a serious inflammation of the stomach, and digestion is either wholly or partly stopped.

(2) **On the Liver.**—The liver is one of the organs which suffers most from the immoderate use of alcohol. In some cases it becomes large and fatty; and in others so hardened that the circulation of the blood through it is obstructed, dropsy and the vomiting of blood being the result.

(3) **On the Heart.**—The effect of alcohol on the heart is to make that organ do one-fourth more work than it ordinarily does; in other words, the rate of its beating is increased from the normal number of 100,000 to 125,000 per day.

(4) **On the Nervous System.**—Through alcohol the nervous system loses all control over the voluntary movements, and the person falls insensible to the ground "dead drunk". Delirium, loss of memory, and insanity are also attributable to alcohol.

THE DWELLING.

LESSONS: THE SITE OF THE DWELLING; A VISIT TO THE NEW HOUSE.

Choosing a Site.—By the term site we mean the land on which a house is built, or is proposed to be built.

In choosing a site, the following points should be borne in mind:—

(1) **The site should be dry.**—Therefore avoid all low-lying

ground; it is not only damp and cold, but receives the drainage of the parts around.

(2) **The site should admit of proper drainage.**—No difficulty in this respect will be experienced if the site is on the slope of a hill.

(3) **The site should be airy.**—It should be freely exposed to the air on all sides, and not surrounded by hills, trees, or high buildings.

(4) **The site should not be on the banks of a river.**—The house is almost certain to be damp, especially if the river is subject to floods.

(5) **Aspect.**—By aspect we mean the position in relation to the points of the compass. On the whole, a south-easterly aspect is perhaps the best.

(6) **Made-soils must be avoided.**—Such soils, consisting as they do of all kinds of rubbish, must prove injurious to health.

Foundations.—Unless the walls of the house are erected upon a firm foundation, sinking or settling is sure to follow. The ground should be excavated to such a depth as will secure a solid bed of earth or rock.

Before commencing to build, a bed of concrete should be laid so as to extend completely under the house, and at least six inches beyond on all sides. It should not be less than eighteen inches thick.

The foundation walls should also be wider at the bottom than above, so as to distribute the weight of the building over a greater area, and thus minimize the danger of settling

To keep the walls dry, a **damp-proof course** should be laid at a point a little above the level of the ground, and a **dry area** formed around the house.

AIR AND VENTILATION.

LESSONS: PRINCIPLES OF VENTILATION; HOW THE AIR IS SET IN MOTION; METHODS OF VENTILATION; SOME MORE VENTILATORS; MORE AIR.

The Air of Open Spaces.—Since human respiration and all fires and lights (except the electric light) remove oxygen from the air and replace it by carbonic acid gas, it would only be natural to think that a time must arrive when the oxygen would be so used up and the carbonic acid gas increased that life could no longer exist. But the analysis of the air in open spaces shows this not to be the case. Plants under the influence of sunlight absorb carbonic acid gas from the air and give out pure oxygen. The fall of rain also removes a little carbonic acid from the air as well as the solid particles. By these ways, therefore, the open air is kept in a state of purity.

Movements of the Air.—When air is heated it expands; hence a given volume of air will not always have the same weight.

A pint of cold air weighs a little more than a pint of warm air. So that if a column of warm air be side by side with a column of cold air, a movement will occur. The warm air will rise and the cold air will take its place. This is exactly how winds are caused.

In a similar way, but on a smaller scale, winds commonly called draughts are produced in our houses. The heat of the fire causes a current of warm air to ascend the chimney, and the cooler outer air flows in through all the openings which exist in the rooms.

Quantity of Air Required.—In order to keep the air of an inhabited room at the proper state of purity, it has been found that each adult must be supplied with 3000 cubic feet of fresh air per hour. Consequently, if the person be living in a room 10 feet long, 10 feet high, and 10 feet broad, that is, containing 1000 cubic feet of air space, the air of the room will have to be changed three times every hour. This change is effected by ventilation.

Method of Ventilation.—Two sets of openings are required—one for the warm, impure air to pass out, and another for the fresh air to come in.

The openings for the exit of air from a room are known as **outlets**, and for the admission of air into a room as **inlets**.

A. **Inlets.**
(1) Windows; arranged on Hinckes Bird's method.
(2) Tobin's Tubes.
(3) Sheringham Valves.
(4) Ellison's Inlets.

B. **Outlets.**
(1) The Chimney.
(2) Chimney Valve (Arnott's).
(3) Boyle's Mica Flap Ventilator.
(4) M'Kinnell's Ventilator.

Artificial Ventilation.—For supplying large and crowded buildings with fresh air none of the preceding plans will suffice; and so it becomes necessary to ventilate such places by the aid of machinery. One system consists in drawing the foul air out, fresh air being allowed to take its place, after being warmed if need be; and in the other system, the fresh air is driven into the buildings along conduits, the foul air escaping by shafts or flues.

WARMING THE DWELLING.

LESSONS: WARMING THE DWELLING; CONCERNING STOVES; WARMING BY HOT WATER.

The various means of heating the dwelling include the following:—

(1) **The Open Fire.**—It is bright and cheerful, and plays an important part in ventilation. The objections to it are: (*a*) Trouble of replenishing with fuel from time to time; (*b*) the great loss of

heat up the chimney; and (*c*) the dust and smoke carried into the rooms by back-draughts.

(2) **The Close Stove.**—This gives great heat, is clean and economical, but does not aid ventilation unless specially constructed. The objections to it are: (*a*) Unsightly appearance in a room; (*b*) causes an unpleasant smell; (*c*) dries the air too much; and (*d*) the danger of carbonic oxide passing into the room.

(3) **The Gas Stove.**—Ventilating gas stoves work very well, but are expensive; and if not properly looked after may allow gas to escape into the air.

(4) **Hot-water** or **Hot-air Pipes.**—These methods are best suited for large buildings, such as schools, theatres, &c.

LIGHTING THE DWELLING.

LESSONS: LIGHTING THE DWELLING; SOME MORE LIGHT.

Artificial lighting is generally effected by means of **candles, lamps, coal-gas,** or **electricity.** In all these methods it must be remembered that all of them, except the electric light, give off impurities to the air, and that every artificial light must be taken into account in questions of ventilation. Coal-gas when burning removes oxygen from the air, and gives off carbonic acid gas, sulphurous acid gas, and water vapou

For the same illumination lamps pollute the air more than gas. Candles are the dearest mean f lighting a room.

On the score of health, the electric light is undoubtedly the best. It gives a splendid light, and does not vitiate the air; but it is very expensive. Next to the electric light, the new incandescent gas-light is undoubtedly the best. It is clean, economical, and sound in principle.

DRAINAGE.

LESSONS: DRAINAGE OF HOUSES; THE DANGERS OF DEFECTIVE DRAINAGE.

Drains are required for the removal of waste matters from the house. In constructing them the following points should be borne in mind:—

(1) The pipes employed should be well glazed inside and outside.
(2) They should be perfectly smooth inside.
(3) They should never pass under the house if it can possibly be avoided.
(4) They should be properly trapped.
(5) They should have a proper fall from the house to the sewer.
(6) They should be made quite water-tight at their junctions.
(7) All waste pipes—such as sink-pipe, bath-room pipe, &c.—

should end in the open air over a trapped gully, and not be connected directly with the drains.

Clogging of Drains.—Drains frequently become clogged or choked from the entrance of bodies which ought never to be thrown down them, such as human hair, tea-leaves, &c.

Drains may Leak.—If the smell of ammonia pervades the house, it is tolerably certain that the drains are at fault. Steps should be immediately taken to have the defects remedied, or the consequences may be very serious. The diseases connected with defective drainage include vomiting, diarrhœa, sore throat, diphtheria, ulceration of the mouth, typhoid fever, and cholera.

WATER SUPPLIES.

LESSONS: WATER SUPPLIES; THE LAST OF THE TALKS.

Necessity of Water.—Water is required for drinking, for many household purposes, for the various trade and manufacturing processes, for watering the streets, for extinguishing fires, &c.

Sources of Water Supply.—The chief sources of our water supply are: (1) Rain, (2) springs, (3) shallow wells, (4) deep wells, (5) rivers, (6) lakes.

Hard and Soft Water.—The hardness of water is due to the mineral matter dissolved in it, the commonest being the **bicarbonate of lime.** Rain-water is **soft**, but all the others are more or less **hard.**

Distribution of Water.—The houses in towns are supplied with water by means of pipes leading from a reservoir, and may be on one of two systems, **constant** or **intermittent.**

In the constant service the main pipes and their branches are always full of water, so that a supply can be obtained at any time by simply turning on the tap within the house. By the intermittent service the water is only turned on for a few hours once or twice a day. The constant supply is much to be preferred.

Cisterns.—In towns supplied by the intermittent method, it becomes necessary to store water for future use in cisterns. These should be made of such materials as will not contaminate the water. Slate is one of the best materials to use.

Characteristics of Good Water:

(1) The water should be free from organic matter.
(2) The water should contain dissolved air.
(3) It should be clear, transparent, sparkling, and palatable.
(4) It should not be too hard.

The presence of organic matter can be detected by adding a few drops of Condy's fluid, the magenta colour of which is rapidly changed if organic matter exists in the water.

EXPLANATIONS OF THE MORE DIFFICULT WORDS AND PHRASES.

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The Visit to Redcliffe.

7. **He was in practice as a physician**; he was a doctor.

to devote to; to give up to, to spend in instructing and amusing.

8. **profession**; calling, occupation. The name is usually given only to callings higher than mere trades or handicrafts, callings that require those who exercise them to have a knowledge of some branch of learning or science.

fostering the boy's desire; making the boy's wish to become a doctor stronger.

9. **the topic of conversation between the boys**; what the boys spoke about.

in animated conversation; talking in a lively way.

The Physiology Class.

10. **had completed his morning rounds**; had visited the patients he needed to see in the forenoon.

Master Workman; God.

contemplation of his own body; looking closely and thoughtfully at the way his body was made.

inspired; guided by divine influence.

11. **do you recognize?** have you found out?

intently; closely, with keen wish to find what was engraved upon it.

12. **microscope**; an optical instrument which magnifies objects when they are looked at through it, or increases the seeming size of objects, and so makes very small objects that cannot be seen by the naked eye visible.

lens; a piece of transparent substance, commonly glass, so shaped that it changes the direction of the rays of

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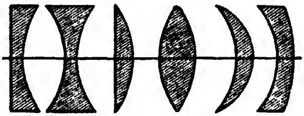
light passing through it, and so makes objects looked at from a certain dis-



tance appear larger or smaller as the case may be.

The Framework of the House I live in.

13. **genial**; kindly, fond of making others happy.

framework; the part of a building to which the other parts are fixed, or which gives shape to the rest.

14. **took occasional peeps**; looked stealthily from time to time.

curiosity; desire for information.

the form of a man is suggested; the person looking at it is forced to think of the body of a man.

carbonate of lime; a substance composed of lime (CaO) and carbon dioxide or carbonic acid gas (CO_2). It is found in the form of chalk, marble, &c.

More About the Framework.

18. **experiment**; an operation performed by the teacher to illustrate a principle or a truth.

impulsive; acting on the feeling of the moment, without thinking enough.

dilute; having its strength reduced by being mixed with water.

20. **To guard against such an occurrence**; to prevent the bone from slipping out of its place.

The Framework is Pulled to Pieces.

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23. **has reached adult age**; is grown up, has become a man or a woman.

As the Twig is Bent the Tree's Inclined.

26. **to lighten them**; to make their load less. They had eaten as much of the fruit as they could

patient; one who is in the hands of a doctor on account of being ill.

27. **unreasonable**; excessive, more than they can bear

the defect has been remedied; they have been made straight again

deformities; departures from regularity or beauty of form. The name is given to whatever takes away very much from the beauty of a thing.

More Deformities.

31. **inflicted**; caused, brought on.

navvies; common labourers engaged in such work as digging canals, making railways, &c.

33. **fully aware of the dangers**; know quite well what harm they risk doing to themselves.

Another Fashionable Deformity.

34. **hobble**; go lamely, limp.

The Covering of the House I live in.

37. **fashionable**; thought by the people of the time to be the proper form.

instruments of torture; means for causing pain or suffering.

38. **sensitive**; possessed of feeling.

The Glands of the Skin.

41. **diagram**; an outline drawing used for illustration.

More about the Glands of the Skin.

44. **evaporates**; is changed from a liquid or solid state into the state of an invisible gas or vapour.

ether; a transparent colourless liquid prepared from alcohol, which, when unconfined, passes rapidly into the state of vapour.

45. **reduces our temperature**; makes us cooler.

The Dead Rabbit.

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48. **calling the attention of his pupils to**; getting his pupils to look carefully at.

How the Muscles Work.

50. **its appearance is altered**; it has been made to look different.

51. **contracting**; growing shorter and thicker (taking up less space).

52. **dismissed**; sent away to play.

The River of Life.

52. **give more definite information**; state more exactly certain ascertained facts.

54. **corpuscle**; a very small body.

How "The River of Life" is kept Moving.

56. **prompted**, led to come to that conclusion and to speak.

The Journey of the River of Life.

59. **Artesian Well**; a well formed by boring perpendicularly into the ground until a supply of water is found. The water rises through the bore by natural gravitation. Some of these wells are very deep.

60. **reservoir**; a place where water is stored.

62. **capillaries**; the very small vessels in which the blood is brought most closely into contact with the tissues to be nourished. These vessels form the connection between the minute terminal arteries, and the veins by which the blood is carried back again to the heart.

A Wonderful Sight.

63. **complete the journey**; trace the blood through the rest of its course in the body.

64. **throbbing**; beating like the heart or pulse.

A Chapter of Accidents.

66. **symptoms**; signs which mark or show a particular disease.

68. **was convinced**; felt certain.

69. **progressing**; improving, getting on.

How the Blood is Purified.

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70. **die of suffocation**; die on account of the want of a supply of air to the lungs.
71. **subdivides**; the divisions divide.

The Air We Breathe.

73. **odourless**; without smell.
75. **smouldering**; burning slowly without flame.

Foul Air.

77. **apparatus**; things gathered together for the purpose of performing an experiment.
79. **inspired air**; the air taken into the lungs.

expired air; the air sent forth from the lungs.

The Dangers of Breathing Impure Air.

82. **encountered a terrible gale**; met a dreadful storm.

tarpaulin; a piece of canvas covered with tar to make it waterproof.

83 **organic matter**; stuff that has formed part of the tissues of a plant or animal, or that has been produced by a plant or animal. The molecule or smallest part that can exist of organic compounds is usually much more complex than the molecule of inorganic compounds.

More Effects of Impure Air.

83. **extreme cases**; instances that seldom occurred.
84. **vitiated**; made impure, or foul.

tale of mischief; amount of harm done.

bronchitis; inflammation of the lining of the bronchi.

consumption; the wasting away or decay of the lung material.

85. **ventilated**; supplied with means for removing the used-up air, and introducing fresh.

Why We Eat.

86. **did ample justice, &c.**; showed by the quantity they ate that they liked them.

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88. **combustion**; burning. Usually the name given to the process whereby the oxygen of the air combines with the material of a body known as a combustible to form new compounds. The most common products of combustion are Water H_2O, carbon monoxide CO, and carbon dioxide CO_2.

What shall we Eat?

90. **tissues**; the bones, muscles, nerves, &c., the substance of the organs of which the body is composed.

analysed; broken up into its constituent parts.

chemical composition; the elements of which a body is composed, and their relative proportions make the chemical constitution.

A Mixed Diet.

92. **different functions**; various offices or duties it performs.
93. **restricted**; limited or bound.

The Digestion of Food.

96. **different patterns**; various shapes or forms.

Swallowing.

98. **summed up the chief points**; recounted in a few words the most important things dealt with.
101. **traversed the length of the gullet**; gone along the passage between the mouth and the stomach.

More about Digestion.

103. **digestion**; conversion into material able to nourish the body.
104. **pipkin**; a small earthen pot.

Indigestion.

106. **appreciate**; value at its true worth.
108. **cause digestive disturbances**; upset the digestion.
110. **fable**; a story intended to teach some useful lesson.

yoke; burden imposed, restraint, rule.

How Messages are sent through the Body.

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111. **complaints**; statements of faults found with persons, things, or systems, put before one in authority.

112. **upon the receipt of the intelligence**; as soon as he learns what's going on.

114. **another curious feature**; another peculiar thing to be noticed about it.

115. **associated**; found in connection with.

More about the Nervous System.

117. **distributed**; divided out; parcelled

How to keep the Brain Healthy.

120. **idiotcy**; hopeless insanity.

Healthy Exercise..

122. **nauseous**; causing sickness.

wearisome and monotonous; tiresome and lacking in variety.

gambolling; frisking; leaping about in play.

124. **deficient exercise**; not using the muscles enough.

confined in splints; bound up with pieces of wood or other substance so arranged as to keep the broken limb in a fixed position.

The Need of Rest.

126. **Shakespeare**; the most famous of English poets, the greatest dramatist the world has produced, was born at Stratford-on-Avon in 1564, and died there in 1616.

127. **robust**; strong and healthy.

Wordsworth; a celebrated English poet born at Cockermouth in Cumberland, 1770, and died at Rydal Mount in 1850.

barrier; boundary; something that separates or divides one thing from another.

complaints; troubles; diseases.

128. **faculties**; powers of mind and body.

129. **Cowper**; a famous English poet born at Berkhampstead in Hertfordshire, 1731, and died at Deneham in Norfolk in 1800.

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129. **Longfellow**; a noted American poet born at Portland, Maine, 1807, died at Cambridge, Massachusetts, 1882.

How to Keep the Skin Clean.

130 **related some of his experiences**; told what had happened to himself.

133 **stimulate it to increased action**; make it act more vigorously.

Why We Wear Clothes.

136 **establishments**; places of business; workshops.

137. **illustrate**; make clear by an example.

More about Clothing.

138. **employed for clothing**; used in making clothes.

139. **considerably reduced**; made much less.

141. **evenly distributed**; spread equally over all parts so as to protect all equally.

The Dangers of Alcohol.

143. **preventable diseases**; forms of illness that, with proper care, need not exist.

occupy the first position; are the most numerous and important.

145. **control**; direct at will.

146. **preserves it**; keeps it from change or decay.

people of intemperate habits; drunkards.

better endured; stood with less suffering and less injury.

The Site of the Dwelling.

149. **sheltered spot**; a place protected by its position from stormy and from cold winds.

A Visit to the New House.

152. **of considerable repute**; very highly spoken of.

get a practical insight; see for themselves how the thing is done.

153. **jerry-builders**; builders who rush up houses for sale, using in building them poor material and poor workmanship, so as to be able to sell them at a low price and yet make a profit.

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153. **seasoned**; dried so that it will not shrink any farther.

154. **door-jambs**; the side pieces or parts that keep up the lintel.

concrete; a mixture of gravel or broken stone and mortar.

155. **porous**; having small spaces between the solid parts through which fluids may pass.

The Principles of Ventilation.

157. **vitiated**; made impure or unwholesome.

161. **apprehend**; be afraid of.

How the Air is Set in Motion.

162. **proving the ascension, &c.**; showing that heated gas rises.

Methods of Ventilation.

165. **occupants of such rooms**; the people who sleep in them.

166. **all that is required, &c.**; all that is needed in order to clear out the impure air.

168. **the same purpose is served**; the foul air is got rid of and fresh air is introduced.

Some More Ventilators.

170. **flush the room thoroughly**; completely sweep out the impure air.

172. **coincide**; lie one over the other.

More Air.

174. **inlet-ventilator**; a contrivance for bringing fresh air into a room.

Warming the Dwelling.

177. **disposed of**; taken up and explained.

enlighten; give the necessary information to.

Concerning Stoves.

184. **products of combustion**; things produced when the gas is burned in air.

Warming by Hot Water.

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188. **equal capacity**; hold the same quantity.

Lighting the Dwelling.

190. **dingy alleys**; dark, narrow, sunless side-streets or passages.

191. **practical science**; science made to contribute to man's material well-being.

192. **snuffing**; the removal of that part of the candle-wick that has been charred by the flame.

greater illuminating power; giving more light.

Some More Light.

195. **coke**; the hard brittle porous substance that remains when the more volatile of the constituents of coal have been driven off by heating it in an oven or retort.

processes; successive stages of manufacture; first one thing has to be done to it and then another.

196. **steatite**; soap-stone.

Drainage of Houses.

198. **sewerage scheme**; a plan for removing the sewage of a town; that is, for carrying away the refuse other than the dry solids and the vegetable refuse.

a difficult problem; a hard thing to do satisfactorily.

The Dangers of Defective Drainage.

202. **ravages of typhoid fever**; the numbers who have died of it.

203. **contaminated**; made impure or poisonous.

Water Supplies.

210. **corroded**; eaten away.

The Last of the Talks.

212. **complaints in the body**; diseases.